State of California
THE RESOURCES AGENCY
Department of Water Resources

BULLETIN No. 106-1

GROUND WATER
OCCURRENCE AND QUALITY
LAHONTAN REGION

JUNE 1964

HUGO FISHER *Administrator* The Resources Agency	EDMUND G. BROWN *Governor* State of California	WILLIAM E. WARNE *Director* Department of Water Resources

Static Test at Edwards Air Force Base

Rocketdyne, A Division of North American Aviation, Inc.

Cooling the hot blast of a rocket engine—a new role for water in the Lahontan Region

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* "20-Mule Team" is a registered trade mark of the United States Borax and Chemical Corporation.

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THE RESOURCES AGENCY OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES

1120 N. STREET, SACRAMENTO

March 11, 1964

Honorable Edmund G. Brown, Governor and
Members of the Legislature of the
State of California
Lahontan Regional Water Pollution Control Board

Gentlemen:

I am pleased to transmit herewith Bulletin No.106-1, entitled "Ground Water Occurrence and Quality: Lahontan Region." Prepared by the Department of Water Resources, this bulletin contains information on the ground water resources in the Lahontan Region, resulting from an extensive investigation of that region by departmental personnel.

The geologic, hydrologic, and water quality studies of the region resulted in the delineation of 55 ground water basins. Within each of these basins, ground waters were analyzed and classified as to their suitability for domestic and irrigation uses. Existing sources of impairment, degradation, and pollution were also noted; such information will serve as a basis for discerning water quality trends in the ground water basins of the region.

The availability of an adequate supply of water of a quality suitable for beneficial uses is the prime factor in the future cultural development and growth in the Lahontan Region--perhaps more so in this arid environ than in any other part of California--and it is the purpose of this report to bring into sharper focus some of the water quality problems which must be overcome if such growth is to occur.

Sincerely yours,

William E. Warne

Director

ACKNOWLEDGMENT

Valuable assistance and data used in this investigation were contributed by agencies of the federal government and of the State of California, by cities, counties, public water districts, and by private companies and individuals. This cooperation is gratefully acknowledged.

Special mention is made of the helpful cooperation of the following:

California Department of Conservation, Division of Mines and Geology

Lahontan Regional Water Pollution Control Board

Los Angeles City Department of Water and Power, Sanitary Engineering Division

Los Angeles County Agricultural Commissioner

Los Angeles County Engineer

San Bernardino County Flood Control District

United States Air Force, Edwards Air Force Base

United States Army, Fort Irwin

United States Geological Survey, Ground Water Branch, Long Beach

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

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Barstow, looking east

Spence Air Photos

The population of the Lahontan Region is concentrated in a few small communities.

CHAPTER I. INTRODUCTION

The Lahontan Region is a part of the largest undeveloped territory available for expansion of the rapidly growing Southern California urban-industrial complex. Because of the generally arid and semi-arid nature of this region, however, the potential for future growth and development within its boundaries is largely dependent upon the availability of adequate supplies of fresh water, of a quality suitable for beneficial uses.

At present, ground water is the primary source of water supply in the Lahontan Region; more than 90 percent of the water used for beneficial purposes is obtained from the ground water basins of the region. However, in some portions of the region the existing supplies of ground water are inadequate, even for current needs. At these points, agricultural development and production, as well as other economic and cultural development has been curtailed because of declining ground water levels or impairment of ground water quality.

At the same time, ground water supplies in other portions of the region either have never been developed, or have been developed only in a very limited way. The additional supply resulting from the full development of these ground water resources would probably alleviate some of the existing water supply deficiencies in the region. But information and data on the availability and quality of this potential source of supply has been inadequate. Therefore, a systematic investigation of ground water basins in the region was undertaken as an initial step in developing this source of supply.

This report presents the results of the geologic, hydrologic, and water quality studies by which 55 ground water basins were delineated in the Lahontan Region, and by which ground and surface waters occurring therein were analyzed and classified for domestic and irrigation usages in the region.

Authorization

The Department of Water Resources has undertaken this investigation as part of the continuing evaluation of surface and ground water quality problems in Southern California. Section 229, Chapter 2, Division 1 of the California Water Code authorizes the department to conduct these investigations:

> "The Department, either independently or in cooperation with any county, state, federal or other agency, to the extent that funds are allocated therefor, shall investigate conditions of the quality of all waters within the State including saline waters, coastal and inland, as related to all sources of pollution of whatever nature and shall report thereon to the Legislature and to the appropriate regional water pollution control boards annually, and may recommend any steps which might be taken to improve or protect the quality of such waters."

In addition, this investigation of the ground water resources of the Lahontan Region has been made in support of the activities of the Lahontan Regional Water Pollution Control Board, and the many local water districts, agencies, water purveyors, and private citizens who have a direct and very real interest in the region's water resources.

Purpose of Investigation

This investigation was undertaken as a necessary prerequisite for the full development of the water supply in the Lahontan Region. The purpose of the investigation was to locate and delineate the ground water basins in the region to make possible a determination of ground and surface water quality in these basins, an important factor in the orderly and efficient development of the area.

Scope of Investigation

During the initial phases of this investigation all available geologic, hydrologic, and water quality data relating to the area of investigation, from the files of the department and other public and private agencies, were reviewed and pertinent information extracted and compiled. This information was supplemented by data from field work by departmental personnel.

Investigations in the field, extending from 1953 to 1962, included geologic reconnaissances; locating wells and measuring water levels; sampling ground and surface waters, and analyzing samples for mineral constituents and radioactivity; and reconnoitering developed portions of the area of investigation to determine land and water use.

Because of the vastness of the Lahontan Region and the reconnaissance nature of most of the field investigations, all ground water basin boundaries were not delineated with equal precision. Some of the boundaries shown in this report were delineated on the basis of previous investigations supplemented by surficial field examination; others, on the basis of rather intensive geologic and hydrologic studies.

Based on these field and office studies, 55 ground water basins were delineated in the area of investigation. To facilitate the study of water resources these ground water basins were considered individually and are reported on individually where possible; the remainder were grouped and are reported on in that manner.

Prior Investigations and Reports

Although this is the first comprehensive study of the entire Southern California portion of the Lahontan Region, many previous studies have been made of portions of the region. In a continuing program, the United States Geologic Survey has cooperated with the Department of Water Resources in mapping surface geology in a number of ground water basins, and in obtaining and publishing well location and water level data for wells in the region.

A list of reports of prior investigations which were consulted during the course of this investigation is presented in Appendix B. Much of the information and data used in the preparation of this report were derived from these sources.

Area of Investigation

In several reports published previously by various agencies, the area of the Lahontan Region included portions of Nevada and Utah, as well as California. The present investigation was limited to that portion of the larger territory within the California borders. For this reason, the term Lahontan Region will be used in this report to designate only the area of investigation; that is, only the diminished portion of the larger region, within the boundaries shown on Plate 1, "Location of Ground Water Basins," will be referred to as the Lahontan Region.

Comprising an area of about 27,000 square miles, the Lahontan Region in California lies generally east and south of the Sierra Nevada.

Its short northern boundary is formed by the Mono drainage divide, and joined on the east by the California-Nevada state line which proceeds to the southeast in a straight line. From the juncture of the state line and the New York Mountains, the southern boundary trends southwest following the drainage divides of the Providence, Granite, San Bernardino, and San Gabriel Mountains. The drainage divides of the Tehachapis and the Sierra Nevada form the long curve of the western boundary.

The area of investigation is in the jurisdiction of the Lahontan Regional Water Pollution Control Board and includes portions of Inyo, Mono, Kern, Los Angeles, and San Bernardino Counties. The principal cities and urban communities are Barstow, Bishop, Lancaster, Mojave, Palmdale, and Victorville.

The physiography, climate, and cultural development of the Lahontan Region are discussed in the remainder of this section.

Topography

The Lahontan Region is divided into two distinct topographic areas, generally north and south of the Garlock fault. A major structural feature of the region, the fault passes south of the Tehachapi and El Paso Mountains; traversing the region in a general northeasterly to easterly direction, the fault passes south of Slate Range and separates the Owlshead Mountains from the Granite and Avawatz Mountains. Near the Silurian Hills the fault turns south and joins the Death Valley fault system.

In general, the area north of the fault is characterized by contrasting extremes of terrain. In this area, there are very high mountain ranges whose jagged peaks and pinnacles give way in a series of precipitous drops to low-lying intermontane valleys. Mt. Whitney at an elevation of 14,495 feet, and Badwater at an elevation of 280 feet below sea level in Death Valley, are both located in this northern portion of the region.

In contrast, the portion of the Lahontan Region south of the Garlock fault is generally characterized by alluviated areas which are relatively flat, broken only by numerous hills and low mountains. These gently rolling surfaces lie about 2,000 feet above sea level and have been formed on weathered granitic bedrock.

Climate

The usual climate of the Lahontan Region is characterized by low annual precipitation and low humidity. Temperatures vary considerably throughout the area, and diurnal variations are often extreme. During certain times of the year, strong winds sweep through the region.

The mean seasonal precipitation in the Lahontan Region, generally increasing with altitude, varies from 1.7 inches or less at stations in the desert valleys to about 50 inches on the higher slopes of the Sierra Nevada. About 75 percent of the seasonal precipitation occurs between November and April, generally in the form of rainfall, although the higher valleys and mountains receive snowfall during the winter months. Precipitation in the desert basins is usually scant but cloudbursts of extreme intensity occasionally flood and damage small areas.

Temperatures near 100° F. are common throughout the Lahontan Region, except at the higher altitudes, during five to eight months of the year. At the Greenland Ranch (Furnace Creek Ranch) in Death Valley a natural-air temperature of 139° F. has been recorded, the highest temperature of record in the United States. However, daily variations in temperatures of 30 degress and occasionally as great as 45 degrees have occurred, and winter temperatures below freezing are quite common.

The winds which are almost constantly present in most of the Lahontan Region are usually from the west; in the eastern portion of the region the wind direction is variable but a southern component usually prevails during most summer months.

Cultural Development

Historically, cultural development in the Lahontan Region centered around irrigated agriculture, the raising of livestock, and mining. Within the last two decades, however, the construction of extensive military installations and manufacturing facilities has resulted in a population influx which has radically changed the earlier patterns of development, particularly in the western portions of the region.

Agriculture. Agriculture and the raising of livestock have long been major economic activities in the Lahontan Region, and their growth has been dependent upon the development of water supplies in the region. Early settlers diverted flows of surface streams in the mountain valleys for the irrigation of forage crops, and for livestock watering. Later, ground water supplies were developed to support increasing acreages of irrigated crops. The fertile lands of the Owens Valley were first developed in the late 1860's; in the Antelope Valley, diversions from mountain streams for agricultural purposes were first recorded in the 1870's.

Big Pine, Owens Valley

Spence Air Photos

The fertile lands of the Owens Valley were first developed in the late 1860's.

About 1880 ground water supplies began to play a more important role in the agricultural development of the Lahontan Region. Artesian wells were drilled in the lower Antelope Valley area, producing good quantities at depths ranging from 200 to 500 feet. The introduction of electric power to this valley in 1914 provided an additional stimulus for the use of ground water for irrigation; by 1950, some 50,000 acres were being irrigated.

Since 1950, however, the area of irrigated agriculture in the Antelope Valley has been decreasing. The lowering of ground water levels in that portion of the Lahontan Region has brought about higher pumping costs, making continued development along these lines uneconomic.

A similar decrease in irrigated agricultural acreages took place in the Owens Valley at a much earlier period, but for a different reason. The growth of the City of Los Angeles had made the acquisition of additional water supplies imperative, as early as 1907. By 1913, the city had begun acquiring and conveying a major portion of the available water from the Owens Valley to the Los Angeles metropolitan area, through the Los Angeles aqueduct. In 1940, almost the entire water supply of the Mono Basin was similarly acquired. As a result, irrigated agriculture has been virtually eliminated from the economy of the Owens Valley and the Mono Basin.

Despite these decreases, however, the total acreage devoted to irrigated agriculture in the Lahontan Region has remained fairly constant; increased acreages in other portions of the region have offset these local decreases.

Mining. Mineral deposits are widespread and mining activity has been economically important in the Lahontan Region since gold was discovered in the 1860's. Both metalliferous and non-metalliferous deposits occur in various portions of the region.

The principal metalliferous deposits are silver, lead, zinc, and iron; tungsten and gold also occur in several mining districts. The major silver, lead, and zinc deposits lie in a belt extending south through the Inyo Mountains, the Argus Range, and the Darwin District of the Northern Slate Range. Most of the larger iron deposits lie south of the Garlock fault near Silver Lake and Cave Canyon; extensive tungsten deposits have been mined near Bishop and Atolia.

In 1949 an important discovery of rare-earth mineral deposits was made in the Mountain Pass District in northeastern San Bernardino County. One deposit, the Sulphide Queen carbonate body, is the greatest concentration of rare-earth minerals now known in the world. Bastnaesite and monazite from this deposit are processed to yield oxides of lanthanum, cerium, and yttrium. The district also contains deposits of barium, strontium, thorium, and minor quantities of other metals.

Non-metalliferous deposits of economic importance occurring in the Lahontan Region include limestone, talc, pumice, perlite, and expansible shales. The limestone deposits occur principally in the Oro Grande, Victorville, and Monolith district; the other minerals are found in local deposits throughout the region.

Saline deposits are being mined extensively in the Searles Lake and the Kramer borate districts. These naturally occurring salt solutions and soluble residues yield commercial quantities of borates, calcium and sodium chlorides, bromines, iodine, and other salts.

Population. The population of the Lahontan Region is primarly concentrated in a few, relatively small urban communities; beyond these small towns and cities, the population is widely scattered in rural and mining settings. Recently, the advent of major military and associated industrial installations in the southern portion of the region, particularly near Barstow, Lancaster, and Palmdale, has produced an influx of permanent residents.

There have also been large increases in the seasonal population of recreation areas in Owens Valley and Mono Basin in the northern portion of the region. This seasonal influx greatly exceeds the number of permanent residents in these areas.

The population of six principal urban centers in the Lahontan Region, based on U. S. Census Bureau data for the years 1940, 1950, and 1960 is shown in the following tabulation:

Population of Principal Urban Centers
of the Lahontan Region, 1940-1960

Year	Bishop	Mojave	Lancaster	Palmdale	Barstow	Victorville
1940	3,000	1,200	3,500	1,400	2,500	2,000
1950	5,700	2,100	8,300	2,700	6,100	3,200
1960	5,800	1,800	33,000	18,800	12,000	8,200

Drainage Basins and Ground Water Basins

The Lahontan Region has been divided into 11 drainage basins with boundaries shown on Plate 1. These boundaries are identical with those given in Water Quality Investigations Report No. 3, "Ground Water Basins in California," published by the Division of Water Resources in November 1952. The boundaries of the drainage basins were established on the basis of physiographic and hydrographic features; each drainage basin comprises an individual watershed, ranging in area from a few square miles to hundreds of square miles.

The ground water basins delineated during the course of this investigation are designated by the numerical code and name shown on Plate 1. They are grouped according to the drainage basin within which they occur, and are discussed in Chapter V according to their numerical sequence within the drainage basin.

CHAPTER II. GEOLOGY

The general geology of the Lahontan Region and the geo-hydrologic relationships in the region are discussed in this chapter. Detailed discussions of those geologic features which significantly affect the hydrology of the major ground water basins are included in the descriptions of the individual basins given in Chapter V.

The objectives of the geologic investigation were to ascertain the areal extent and water-bearing characteristics of the various geologic materials in the Lahontan Region; to determine the hydrologic significance of the prominent structural features of the area; to locate and evaluate the hydrologic characteristics of the ground water basins identified in the region; and to determine the mode of occurrence, the movement and the ultimate destination of ground water.

The areal geology was compiled from published and unpublished data, and from extensive reconnaissance field mapping. Because the geologic investigation was primarily a study of geology as related to water resources, and particularly the ground water supply, the geology of the nonwater-bearing rock was not intensively investigated. However, the results of previous investigations of these geologic materials were checked in the field and structures that appeared to influence the occurrence or movement of ground water were studied more thoroughly.

The physiography, soil morphology, geologic units, structure, and geologic history of the Lahontan Region are discussed in this chapter. The major geologic features of the individual ground water basins are discussed in greater detail in Chapter V.

Spence Air Photos

Anvil Spring Canyon—Looking East to Death Valley.

Physiography

Of the eleven geomorphic or physiographic provinces comprising the State of California, portions of four are in the area of investigation: the Transverse Ranges, Sierra Nevada, Basin-Ranges, and Mojave Desert provinces (Jenkins, 1943). The most striking physiographic features of each of these four provinces within the Lahontan Region are described in this section.

Transverse Ranges Province

The Transverse Ranges province is an elongate structural unit trending east-west for a distance of about 225 miles across portions of Santa Barbara, Ventura, Los Angeles, San Bernardino, and Riverside Counties. The province ranges in width from about 50 miles at its western end, to 15 miles in the Cajon Pass area, and 30 miles in the middle part of the San Bernardino Mountains.

The Transverse Ranges province has been classified by Bailey and Jahns (1954) into 13 topographic units. Of these only the San Gabriel and San Bernardino Mountains lie within the investigational area. The topography of much of the area indicates a late youthful to early mature state of erosion. Sharp, rugged ridges and narrow, steep-sided, deeply incised valleys characterize the more youthful areas. Most of the streams are intermittent and flow only during the winter and spring. Several large alluvial fans have formed at the mouths of the canyons from streams discharging onto the floors of the Antelope Valley and the Upper Mojave River Basin. The province contains numerous marine and nonmarine terraces, upland surfaces of low relief, and fault controlled valleys and canyons.

Sierra Nevada Province

Extending for over 400 miles from the southern Cascade Range south-southeast to the Tehachapi Mountains is the Sierra Nevada, the greatest of California's mountain ranges. It is the most nearly continuous and the highest range in California, reaching its maximum elevation of 14,495 feet at Mt. Whitney. The Sierra Nevada is a westward-tilted block with a steep, high eastern front and a relatively gentle western slope. The portion of the province lying within the area of investigation contains extensive evidence of past glacial activity. Lateral, medial, terminal, and recessional moraines are prominent along the western side of Owens Valley. Glacial lakes or "tarns", hanging valleys, and cirques are further evidence of glacial activity in the Sierra Nevada province.

Basin-Ranges Province

The portion of the Basin-Ranges province in the area of investigation lies north of the Mojave Desert and east of the Sierra Nevada provinces. Interior and integrated drainage, saline lakes, and desert climatic conditions characterize the area. A large number of northwest trending mountain ranges, desert plains, and basins are in the area. The grabens or troughs which lie between the northwesterly trending mountain blocks are generally long and narrow, bordered by precipitous slopes, with playas at points of lowest elevation. This province also contains alluvial fans and aprons, fault features, shore features of ancient Pleistocene lakes, and abandoned drainage courses.

Mountains which trend in a northwesterly direction are fault-controlled whereas numerous others are erosional remnants and have no definite pattern. Among the former are the Inyokern Mountains (maximum elevation 11,127 feet), Panamint Mountains (maximum elevation 11,345 feet), Slate Range (maximum elevation 5,093 feet), Black Mountains (maximum elevation 6,384 feet), Argus Range (maximum elevation 6,562 feet), and the White Mountains (maximum elevation 14,242 feet). Mountains which have no definite trend include the Kingston Range (maximum elevation 7,320 feet), Owlshead (maximum elevation 4,675 feet), and the Quail Mountains (maximum elevation 5,103 feet). Owens, Panamint, and Death Valleys comprise the valley portion of the Basin-Ranges province.

One of the most interesting physiographic features of the Basin-Ranges province is the surface expression due to volcanic activity. At no other point in the Lahontan Region are the volcanic rocks so diverse or so well displayed. A volcanic field, consisting of numerous cinder cones and lava flows, occurs between Big Pine and Independence in Owens Valley. Crater Mountain, the most prominent of these craters, rises 2,000 feet above the valley floor. Mono Craters extend southward from Mono Lake for about 10 miles, and consist of cinder cones as high as 2,700 feet.

Mono Lake, in the extreme northerly portion of the province, occupies a fault basin east of the central portion of the Sierra Nevada. Mono Lake is about 14 miles wide, 10 miles long, and has a maximum depth of 150 feet. During the last two glacial episodes, this area was occupied by a much larger body of water, Lake Russell, which was about 900 feet deep.

Mojave Desert Province

The Mojave Desert province is separated from the Basin-Ranges province on the north by a line which corresponds in part to the trace of the Garlock fault. The province is bordered on the northwest by the Sierra Nevada and on the south and southwest by the Colorado Desert and the Transverse Ranges.

The portion of the province in the area of investigation is characterized by broad regions of mountain ranges separated by vast desert plains. Isolated hills such as Castle Butte (elevation 3,145 feet) and Black Butte (elevation 3,684 feet), and mountains such as Red Mountain (elevation 5,270 feet) and the Shadow Mountains (elevation 4,039 feet) rise above the plains. The mountain ranges in the Mojave Desert province are also lower in elevation and more deeply dissected than those to the north. Extensive areas of extremely low relief contain basins whose size, shape, and arrangement vary widely. Drainage is enclosed and integrated.

Evidence of volcanic activity is not prominent and evidence of glaciation has not been observed. Playas, alluvial fans, and sand dunes occur throughout the province. The Mojave River, one of the largest rivers in the Lahontan Region occurs in this province, extending about 115 miles from its headwaters in the San Bernardino Mountains to its terminus in Soda Lake.

A recurrent physiographic feature of the desert basins is the playa, or dry lake which occurs in the lowest areas of surface drainage. Playas are generally sites of deflation, rarely subject to deposition of sediments. The thickness of the playa deposits of Recent age has not been determined accurately but it is probably as great as 100 feet in the larger playas. Older underlying lake sediments which are much thicker, were deposited during the Pleistocene. The section through an idealized desert ground water basin, shown as Diagram 1, indicates general playa

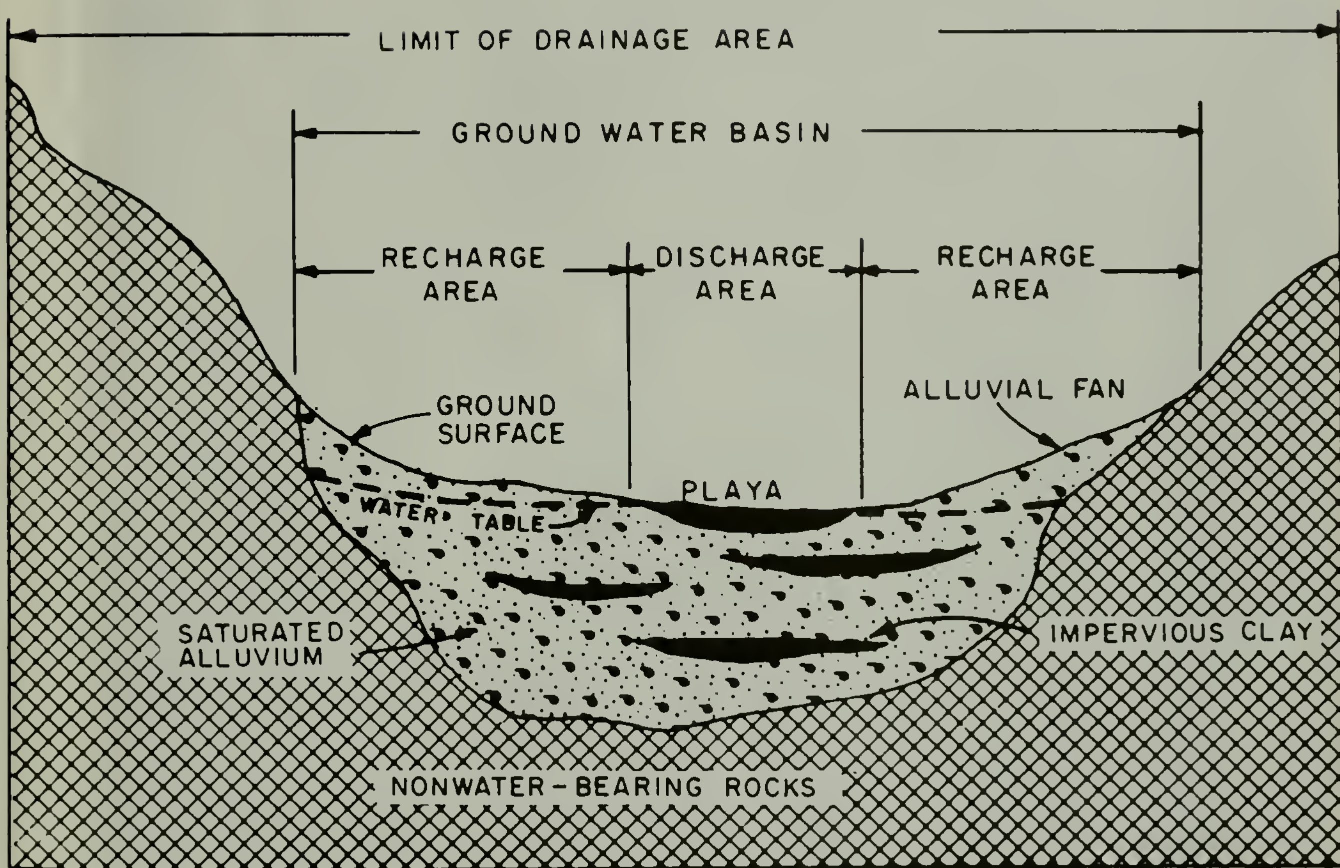


DIAGRAM I. SECTION THROUGH AN IDEALIZED DESERT GROUND WATER BASIN

Chemical Plant on Searles Lake near Trona — Spence Air Photos

The mining and processing of salt from deposits in the Lahontan Region are major industrial activities.

characteristics. On the basis of subsurface drainage conditions and approximate depths to water, Stone (1952) has classified playas into five types: dry, moist, compound, crystal body, and artificial.

The dry playa has a hard, smooth, flat, usually cracked surface which is wet only during or immediately after periods of rain. Its sediments have a low concentration of soluble salts but a high concentration of calcium carbonate. The water table is located more than ten feet below the playa surface, and ground water probably has a subsurface route of escape, otherwise the water table would eventually rise above the ten-foot limit.

The moist type playa exhibits an irregular puffy, rolling surface and has a thin fragile or brittle crust of salt or clay. Beneath this crust is a layer of soft, spongy ground, with a honeycomb structure. The water table is within ten feet of the surface. Moist playas can be differentiated into those that have a clay-encrusted surface and those that have a salt-encrusted surface.

The compound playa is formed by the rise and the fall of the water table through the ten-foot limit and this type has characteristics of both the dry and moist types.

The crystal body playa overlies a zone of nearly pure salt. The interstices of this salt body are filled with brine. The crystal body may occur near or at a considerable depth below the surface. In Searles Dry Lake, for example, the top of the crystal body lies at a depth of 90 feet. The portion of the playa which surrounds the area directly overlying the crystal body is usually of the moist, salt-encrusted type. The thick, buried salt deposits of crystal body playas probably

TABLE 1

PLAYA LAKES IN THE LAHONTAN REGION

Ground water basin containing playa lake: Number	Ground water basin containing playa lake: Name	Name of playa lake	Location	Approximate area in square miles	Type	Use at present
6-10	Adobe	Black	T1N, R30E[a]	0.4	Compound	None
6-12	Owens	Owens	T16-19S, R36-38E[a]	96	Artificial	Commercial recovery of salt deposits
6-15	Deep Springs	Deep Springs	T8S, R36E[a]	1.8	Moist, salt encrusted	None
6-16	Eureka	Eureka	T9-10S, R39E[a]	1.4	Dry	None
6-17	Saline	Salt	T14S, R38-39E[a]	19	Moist, salt encrusted	None
6-18	Death Valley	Death Valley	T16-18S, R46E[a] T22-28N, R1-2E[b]	176	Moist, salt encrusted	None
6-21	Valjean	Silurian	T17N, R7-8E[b]	2.1	Dry	None
6-23	Riggs	Riggs	T15-16N, R8E[b]	2.2	Dry	None
6-24	Red Pass	Red Pass	T13-14N, R6E[b]	1.2	Dry	Military
6-25	Bicycle	Bicycle	T14N, R3E[b]	2.1	Dry	Military airport
		McLean	T16N, R2E[b]	0.5	Dry	Military
		Nelson	T16N, R2E[b]	1.0	Dry	Military
6-27	Leach	Leach	T17-18N, R3E[b]	2.1	Compound	Military
6-28	Pahrump	Pahrump	T22-23N, R9E[b]	10	Dry	None
		Stewart	T24N, R7E[b]	6	Moist	None
6-29	Mesquite	Mesquite	T18-19N, R13E[b]	7	Moist, clay encrusted	None
6-30	Ivanpah	Ivanpah	T16-17N, R14-15E[b]	31.0	Dry	None
6-32	Broadwell	Broadwell	T8-9N, R7-8E[b]	3.5	Dry	None
6-33	Soda Lake	Soda	T12-14N, R8-9E[b]	40.7	Compound	None
6-34	Silver Lake	Silver	T14-15N, R8E[b]	3.2	Dry	Emergency landing field
6-35	Cronise	Cronise - east	T12N, R6-7E[b]	2	Dry	None
		Cronise - west	T12N, R6E[b]	1.6	Moist, clay encrusted	Clay mining

PLAYA LAKES IN THE LAHONTAN REGION
(continued)

Ground water basin containing playa lake: Number	Name	Name of playa lake	Location	Approximate area in square miles	Type	Use at present
6-36	Langford	Langford	T13N, R3E[b]	1.0	Dry	Military
6-37	Coyote Lake	Coyote	T11-12N, R2E[b]	9.1	Dry	None
6-39	Troy	Troy	T8-9N, R4E[b]	5.3	Moist, clay encrusted	None
6-40	Lower Mojave	Calico	T10N, R1E[b]	2.1	Dry	None
6-43	El Mirage	El Mirage	T6-7N, R6-7W[b]	5.2	Dry	None
6-44	Antelope	Buckhorn	T9N, R10W[b]	3.0	Compound	None
		Rodgers	T9-10N, R8-10W[b]	43.3	Dry	Military
		Rosamond	T8-9N, R11-12W[b]	20	Compound	Clay mining
6-45	Proctor	Proctor	T32S, R34E[a]	1.2	Intermittent	Grazing land
6-46	Fremont	Koehn	T30S, R38E[a]	5.0	Moist, salt encrusted	Commercial recovery of salt deposits
6-47	Harper	Harper	T11N, R3-4W[b]	16	Compound	None
6-48	Goldstone	Goldstone	T14-15N, R1E[b]	1.8	Dry	Military
6-49	Superior	Ausland	T31S, R46E[a]	2.6	Dry	None
		Middle Superior	T31S, R46E[a]	0.7	Dry	None
		West Superior	T31S, R45E[a]	3.1	Dry	None
6-50	Cuddeback	Cuddeback	T30-31S, R42E[a]	6.3	Dry	None
6-52	Searles	Searles	T25-26S, R43-44E[a]	40	Crystal	Commercial recovery of salt deposits
6-53	Salt Wells	--	T26S, R41-42E[a]	0.7	Dry	Military
6-54	Indian Wells	China	T25-26S, R40-41E[a]	7.0	Moist, clay encrusted	Military
6-55	Coso	Airport	T23S, R39E[a]	2.0	Dry	Military
6-56	Rose	--	T22S, R38E[a]	0.5	Dry	None
6-58	Panamint	Upper Panamint	T17-19S, R42E[a]	6.6	Dry	None
		Lower Panamint	T21-23S, R44E[a]	17.5	Moist, clay encrusted	None
6-71	Lost Lake	Lost	T19N, R1E[b]	4.4	Dry	None

a. M.D.B.&M.
b. S.B.B.&M.

resulted from a single cycle of evaporation of large Pleistocene lakes under arid conditions. Overlying or interbedded mud layers are sediments which were deposited during the periods of moist climatic conditions.

There are a few artificial playas as a result of man's activities. The best example of an artificial playa is Owens Dry Lake. This dry lake resulted from diversion of the natural surface water replenishment to Owens Lake and evaporation of the existing water body.

Data on location, area, type,and use of the playa lakes are listed on Table 1.

Soil Characteristics

The desert soils of the Lahontan Region are usually light in color, are generally deficient in phosphorus and nitrogen, and are usually lacking in organic matter. Except on river terraces and a few other older alluvial land forms, the soils appear to have little profile development. In the northern and eastern portions of the region the soils appear somewhat coarser than those in the western and southern portions; the action of the prevailing winds is a dominant factor in the region, creating desert pavements in some areas.

The texture of the soils on the upper slopes of the alluvial fans is generally coarse, and the combination of soil texture and terrain makes these upper slopes generally unsuitable for most agricultural uses. Finer textured soils are found on the lower slopes of the fans, on the piedmont plains, and in the playas. The soils and terrain of the lower slopes and plains permit these areas to be used for agriculture, but the dense clays and the high salinity of most of the playa soils generally prohibit the use of playas for agricultural purposes.

The soils in most of the region support light to heavy cover of typical desert flora. Desert bunch grass and desert sage flourish in areas of better soils, and creosote bush is interspersed with Joshua trees at certain elevations.

Geologic Units

Ground water occurs in several different types of geologic materials in the Lahontan Region. Almost all of the readily extractable ground water is stored in the larger alluvial-filled valleys, which have a distinct shape, depth, and permeability. The valley fill is eroded from the surrounding highlands and varies from unconsolidated to poorly consolidated water-bearing alluvium of variable thickness. It is composed of flood plain and alluvial fan deposits which range in age from Recent to Pliocene. Small quantities of ground water are also found in older sediments and in the volcanic rocks which flank or underlie several of the alluvial-filled valleys.

The mountains of the desert region consist of sedimentary, igneous, and metamorphic rocks ranging in age from Precambrian to Quaternary. These various rock types underlie the basins forming the impermeable sides and bottoms of the basins.

In the following descriptions of geologic units, the geologic formations or units of the Lahontan Region have been differentiated with respect to their hydrologic properties and their lithologic characteristics into unconsolidated deposits and consolidated rocks. Table 2 presents a brief description of these units.

TABLE 2

GEOLOGIC UNITS

Geologic age		Geologic	Areal extent	General character	Water-bearing characteristics
System	Series	unit			
			UNCONSOLIDATED DEPOSITS		
Quaternary	Recent and Upper Pleistocene	Alluvium	Underlies nearly all of the lowlands as valley fill and is exposed along creek beds and arroyos.	Consists of interstratified, interfingered, discontinuous beds, lenses and stringers of poorly to fairly well sorted sand, gravel, silt, and clay deposits. Most alluvium has been deposited as fans. It is coarse around the edges of the basins but becomes finer-grained and better sorted toward the playas or central portions of the basins. In most basins, alluvium probably rests with minor local unconformity on older deposits. Elsewhere, alluvium probably rests with moderate to marked unconformity on erosional surfaces of older rocks.	Where saturated, alluvium is the primary water-bearing material. In general, it has the highest permeability of any of the geologic units, and is capable of yielding water relatively freely to properly spaced and constructed wells. Finer grained phases are usually lower in permeability but may contain ground water. This unit will readily permit the percolation of water to underlying deposits.
Quaternary	Recent and Upper Pleistocene	Dune sand	Generally of limited extent but found most often locally along the edges of playas. One of the larger accumulations occurs south of Soda Lake near Crucero.	Dune sands are buff colored, medium to fine-grained, subrounded, and consist of quartz, feldspar, and other rock fragments. The materials have been deposited by wind action and usually attain a maximum thickness of 20 to 30 feet.	The sands are highly porous and permeable, but generally are above the water table.
Quaternary	Recent and Upper Pleistocene	Playa deposits	Numerous deposits occur which are variable in size and type. Generally, they are found near the central lower portions of the valleys.	The deposits consist of well sorted clays and fine sands that have been deposited in shallow bodies of standing water. This unit unconformably overlies deposits of Tertiary and/or Quaternary age and/or older alluvial deposits. Laterally the playa deposits interfinger with alluvium of Pleistocene or Recent age.	The poor quality low yield of water from wells in the playa deposits is due to the saline character and the high clay content of the materials underlying the dry lakes.
Quaternary	Pleistocene	Pleistocene Lake deposits	Largest outcrops are found north of Mono Lake, on both sides of Long Valley, and south of Shoshone. Smaller deposits are found in many other areas.	The lake deposits are composed predominantly of well sorted, clean, cross-bedded sands, interbedded with lenses of fine silt and clay. They are underlain by finer-grained sediments similar to playa deposits. Well preserved shore terraces and gravel bars indicate the locations of many of the old lakes.	These deposits generally have a low permeability due to their clay content. These sediments probably will not yield water freely to wells.

GEOLOGIC UNITS
(continued)

Geologic age: System	Geologic age: Series	Geologic unit	Areal extent	General character	Water-bearing characteristics
			UNCONSOLIDATED DEPOSITS (continued)		
Quaternary	Pleistocene	Pleistocene glacial deposits	Large deposits occur southwest of Mono Lake and west of Bishop on the flanks of the Sierra Nevada.	This unit consists of scattered boulders, glacial moraines and outwash, and fresh moraines confined mainly to cirques.	Although large quantities of good quality ground water are stored in these deposits, very few wells tap this unit for a water supply because drilling in this coarse material is very difficult.
Tertiary-Quaternary	--	Tertiary and/or Quaternary sediments	Outcrops occur in many parts of the region. This unit includes older alluvium, dissected fan deposits of Pleistocene age, and older fan deposits.	This unit varies from well-bedded sands, silts, shales, and conglomerates to megabreccias. Dips range from one to 20 degrees. Sediments in this unit are usually coarser at the base grading upward into finer materials. Some slopes are slightly dissected whereas others are deeply incised. Metaigneous, metasedimentary, and volcanic debris comprise this unit.	These deposits generally underlie younger alluvium and are saturated. Many of the deeper wells probably tap this unit as their source of supply.
			CONSOLIDATED SEDIMENTARY, IGNEOUS, AND METAMORPHIC ROCKS		
Quaternary	--	Quaternary volcanic rocks	Volcanic rocks occur locally throughout the region with the largest outcrops occurring due north of Bishop and south of Mono Lake.	The volcanic rocks consist of basalt, latite, andesite, dacite, and obsidian associated with tuff, tuffaceous sand, agglomerates, and pumice. This unit varies in thickness, and may be as thick as 1,000 feet.	Because of their dense crystalline texture these volcanics are considered to be nonwater-bearing. The amount of water available to wells drilled in this unit depends on the extent to which the unit contains open fractures capable of storing and transmitting water.
Tertiary-Quaternary	--	Tertiary-Quaternary volcanic rocks	Numerous outcrops are found in the Lahontan Region	Latite and andesite are the chief rock types composing this unit, but dacite, basalt, and obsidian occur in lesser quantities. This unit is principally extrusive and rests unconformably on basement complex or consolidated older Tertiary sediments.	Although this unit is generally impermeable and nonwater-bearing, wells obtain water from joints, fractures, and fissures.
Tertiary-Quaternary	--	Tertiary-Quaternary sediments	The largest outcrops occur east of Olancha and in the northeasterly portion of Panamint Valley. Smaller outcrops occur in many other areas.	Several formations have been grouped into this unit because of lithologic similarities. It predominantly consists of consolidated to semiconsolidated light-colored, coarse sandy gravels and partially cemented sands, silts, and clays. Folding and faulting have occurred in many places.	The water-bearing potential of this unit is rather poor because of its fine-grained materials and because it generally lies above the water table.

GEOLOGIC UNITS
(continued)

Geologic age: System	Geologic age: Series	Geologic unit	Areal extent	General character	Water-bearing characteristics
			CONSOLIDATED SEDIMENTARY, IGNEOUS AND METAMORPHIC ROCKS (continued)		
Tertiary	--	Tertiary sediments	Relatively small outcrops are exposed throughout the region	These formations are composed of tuff, chert, siltstone, sandstone, and conglomerate. Coarse cobble conglomerates of granitic and volcanic debris predominate in some areas, whereas, finer grained sediments and tuffs are more abundant elsewhere. The maximum thickness of any formation included in this group is probably 7,000 feet. Weather resistant cliffs have been formed in some areas where basalt flows have capped the sediments. This unit includes several distinct formations having similar lithologic characteristics which range in age from Miocene to Pliocene.	This unit is considered nonwater-bearing. Permeability is low because of partial cementation and lithification of the material.
Tertiary	Miocene	Tertiary volcanic rocks and sediments	The unit includes several formations and is exposed extensively in the Lahontan Region	This unit consists of intrusive and extrusive volcanic rocks and continental sediments which probably range in age from middle through upper Miocene. The predominant rock types are andesites and dacites with some basalts and tuffs. Fanglomerates, breccias, arkosic sandstones and conglomerates, and beds of siltstone and clay stone are interbedded with the volcanic rocks.	The sedimentary phases are highly indurated and have low permeability. Deep wells which tap these rocks may obtain small quantities of water but generally the unit is nonwater-bearing.
Tertiary	--	Tertiary volcanic rocks and sediments	The volcanic rocks are distributed throughout the region with the largest exposure occurring near Mono Lake.	This unit comprises latites, andesites, dacites, basalt flows, and pyroclastics. The andesites, latites, and dacites crop out as plugs, dikes, and small flows.	Although the unit is essentially nonwater-bearing, moderate quantities of water may be stored in fractures, fissures, planes of lamination, or weathered zones.
Triassic	--	Triassic metasediments and metavolcanic rocks	The unit is limited in extent. The largest exposures occur east of Helendale and north of Owens Lake.	This unit comprises highly altered dacite and andesitic flows, pyroclastics, tuffs, breccias, conglomerates, and limestones. Fresh exposures are few because deep weathering has produced a soil mantle. The sediments and volcanics are schistose and gneissic.	The permeability is generally low, but weathering, aided by the schistose and slatey nature of the rocks possibly have created some storage. Small domestic wells possibly could obtain water from weathered phases and from joints and fissures.

GEOLOGIC UNITS
(continued)

Geologic age		Geologic unit	Areal extent	General character	Water-bearing characteristics
System	Series				
			CONSOLIDATED SEDIMENTARY, IGNEOUS AND METAMORPHIC ROCKS (continued)		
Precambrian and Paleozoic	--	Precambrian Paleozoic sediments and metasediments	The largest exposures are in the Inyo Mountains, Last Chance Range, northern Panamint Range, and in the Funeral and Grapevine Mountains.	Carbonate rocks predominate whereas quartzites and clastic sediments occur in lesser quantities.	This unit is considered to be impervious and nonwater-bearing, but minor quantities of water are stored in the fractures and joints where they sometimes issue as springs.
Jurassic to Cretaceous	--	Granitic rocks	The unit is well exposed in most of the region.	This unit consists of plutonic igneous rocks which vary in composition from granites to gabbros.	Joints and fractures provide small quantities of water to wells and springs.
Precambrian to Jurassic	--	Metamorphic rocks	Small outcrops occur in many parts of the region.	This unit includes metasediments, metavolcanic, and metaigneous rocks. The dominant rock types are schists, gneisses, crystalline limestones and metaconglomerates.	The slatey cleavage and schistosity of the rocks aid weathering. Small amounts of water can be obtained from the weathered portions of the unit and from the joints and fractures.
Precambrian to Jurassic	--	Undifferentiated rocks	The unit occurs throughout the region.	This unit consists of igneous, metamorphic, volcanic, and sedimentary rocks which have not been differentiated in this report.	Joints and fractures supply small quantities of water to wells and springs

Unconsolidated Deposits

The unconsolidated deposits comprise the following units: alluvium, dune sand, playa deposits, Pleistocene lake deposits, Pleistocene glacial deposits, and Tertiary and/or Quaternary sediments. The geologic characteristics of these deposits are discussed in this section.

Alluvium. Alluvium underlies the undissected alluvial surfaces of the lower valley areas. Alluvium is exposed between the lower margins of alluvial fans and the upper edges of the playas and in creek beds and arroyos. It has a greater areal extent than any other unit in the water-bearing group. Alluvium increases in thickness from the edges of the basins to their central portions. The central portions of the basins are underlain by unconsolidated alluvial debris probably more than 1,000 feet thick, which was deposited during late Pleistocene to Recent time.

Alluvium consists of unconsolidated deposits of clay, silt, sand, and gravel. Some of the clean sands and gravels form the most prolific water-bearing sediments. Other deposits are poorly sorted and some contain a large amount of fine material. Some deposits were subjected to long periods of weathering before they were buried and now contain a large amount of residual clay. The finer sediments include both silts and clays.

Generally, alluvial materials of the same lithology are not continuous over extensive areas. The more permeable strata occur in stringers and lenses that are usually surrounded by less permeable sediments. Such stringers and lenses were deposited in the channels of streams which gradually filled the basins with alluvial material. While the stream channels were being filled with sands and gravels, surrounding interstream areas received only fine deposits from sheet flooding and overflowing of the stream channels. Weathering has also increased the amount of residual clay in the deposits. Thus, weathering and these various modes of deposition account partly for the nonhomogeneous distribution of the alluvium.

The principal water-bearing sediments in the region are usually found in the alluvial deposits. The water-bearing sediments are neither compacted nor cemented and the sands and gravel are usually highly permeable.

Dune Sand. The sand dunes in the Lahontan Region are actively drifting, but locally they are obstructed or are anchored by vegetation. The sand dunes usually are a few feet thick, but in some areas they are several tens of feet thick. The largest deposit is south of Soda Lake in San Bernardino County and extends from Crucero, on the west, to Kelso about 21 miles to the east. Other large deposits occur along the periphery of the dry lakes. Many of the smaller dunes were formed by deflation of the Recent alluvium, older sediments, or playa deposits.

The dune sand deposits usually lie above the water table and are unsaturated. However, they are porous and permeable and will readily transmit any water falling on their surfaces to underlying sediments.

Playa Deposits. The playa deposits are widely distributed in the region. Individual playas vary in area from less than one square mile to as much as 175 square miles. The playa deposits which underlie the surfaces of the dry lakes have accumulated from material in shallow bodies of standing water that covered the lower portions of the basins during floods. The thickness of the playa deposits ranges from a few feet to as much as 100 feet. In some areas, wind action is eroding and removing playa deposits. The playa deposits probably overlie deposits of Tertiary and Quaternary age unconformably and interfinger laterally with alluvial debris of late Pleistocene and Recent age.

Fine sands, silts, and clays compose the playa deposits except along the periphery of the playas where alluvium interfingers with playa sediments. Blue or green Pleistocene lacustrine deposits often underlie the buff or brown surface deposits.

The fine-grained playa deposits generally have a low permeability, and even when they are saturated, yield very small quantities of water to wells. Where they act as confining beds, playa deposits often cause artesian conditions in the underlying sediments.

Pleistocene Lake Deposits. These deposits of late Pleistocene age are exposed north of Mono Lake, on both sides of Long Valley, south of Shoshone, and in many other areas in the Lahontan Region. The largest outcrops are on both sides of the Amargosa River south of Shoshone and have been mapped as the Tecopa beds by Mason (1948). In surface expressions these beds are characterized by badland topography. Lake Tecopa probably occupied an irregular basin which was about 15 miles in diameter. The lake was fed by the Amargosa River, which flowed in a southward direction and had an outlet south of Tecopa. Downcutting of the outlet led to draining of the lake and dissection of the lake deposits.

The lake deposits generally consist of silts and sands with subordinate layers of volcanic ash and bentonite. The sands are frequently well-sorted, and crossbedded, and are interbedded with lenses of fine silt and clay. Although many surface exposures are well-sorted sands, the lake deposits are thin and may be underlain by fine-grained sediments which probably would not yield copious amounts of water.

The lake beds are exposed along the highway leading from Baker to Barstow. These well-indurated clay and sand beds which are dissected and slightly deformed, attain a thickness of about 75 feet. About 25 miles west of Baker, a well-preserved gravel bar marks the former position of the shore of Lake Manix, which in Pleistocene time covered an area of about 200 square miles.

Pleistocene Glacial Deposits. The principal Pleistocene glacial deposits consist of moraines occurring locally along the eastern foothills of the Sierra Nevada. The largest exposures occur in Inyo and Mono Counties in the vicinity of June Lake, in the Round Mountain area west of Big Pine, and on the mountain slopes north of Camp Sabrina.

Most of the glacial moraines are 50 feet to 100 feet high with some moraines forming ridges which are 200 to 300 feet high. Material comprising this unit varies in size from clay to very large boulders. Most of the glacial deposits are characteristically unstratified and include numerous rock types. Because very little soil has been developed on the moraines, they are nearly devoid of vegetation.

The Pleistocene glacial deposits are porous, permeable, and capable of storing and transmitting water. Because of their topographic location, however, most of these deposits can be drained easily and therefore may contain little water. Drilling is expensive in the morainal material so few wells tap the moraines as a source of water supply.

Tertiary and/or Quaternary Sediments. This geologic unit comprising older alluvial fan, lacustrine, and saline deposits, is exposed in many parts of the Lahontan Region. The largest exposure extends northward from the base of the San Bernardino Mountains and follows the course of the Mojave River through Victorville to Helendale. At Helendale, the river turns eastward, whereas the geologic unit follows a tributary to a point about 12 miles northwest of Helendale.

Near Zurich, in the northwestern part of Inyo County, the unit is well exposed in a dissected alluvial fan which is about 200 feet thick. This fan was mapped as the Waucoba Beds by Walcott (1897). The unit also includes a tilted block of older alluvium located south of Barstow. The unit underlies most alluvial deposits in the basins and it may be as much as 2,000 feet thick.

The Tertiary and/or Quaternary sediments are slightly to moderately deformed with dips ranging from 1 to 20 degrees. These sediments are the oldest deposits of the unconsolidated series. The sediments generally rest unconformably on older, consolidated sedimentary rocks or on igneous or metamorphic rocks. The stratigraphic position and the slight deformation indicate that these deposits are late Tertiary to early Quaternary in age; this is confirmed by fossil evidence in the Afton Canyon area.

This geologic unit consists predominantly of sediments originating from a variety of igneous and metamorphic rocks. Lesser amounts of volcanic detritus have been deposited as alluvial fan, flat-lying flood plain, and lacustrine deposits. The sediments are generally well sorted in a few areas but very poorly sorted in other localities. In the area between Goldstone and Coyote Lake, near Camp Irwin, the material is generally coarse at the base of the unit and grades upward into finer phases.

The water-bearing character of the Tertiary and/or Quaternary sediments varies. The upper portions of the unit are often deeply weathered and contain abundant clays yielding little water to wells. In areas where the unit underlies and merges with younger sediments, it is saturated, but wells that tap this unit for ground water supply are usually more than 100 feet deep. Some domestic wells obtain small quantities of water from older alluvium south of Barstow.

Consolidated Sedimentary, Igneous, and Metamorphic Rocks

The consolidated sedimentary, igneous, and metamorphic rocks are generally nonwater-bearing. They include five igneous and metamorphic rock units which range in age from Precambrain to Traissic, and six younger units which include various types of volcanic rocks and associated sediments ranging in age from early Tertiary to Quaternary.

In the Lahontan Region, more than one hundred formations have been differentiated within these categories but because this report is primarily concerned with the water-bearing potential of rocks, the nonwater-bearing rocks are not discussed in detail. However, they have been grouped into the eleven major units described on Table 4.

Structure

The rocks in the Lahontan Region have been greatly deformed by faulting and, to a lesser degree, by folding. Although the San Andreas and Garlock faults are the largest prominent faults in the region, smaller and less apparent faults are more important hydrologically because they may obstruct ground water movement and thus form the basis for dividing the larger ground water basins into smaller entities.

Faulting

Because many of the numerous faults in the region are masked by alluvial materials, their magnitude and extent are unknown. The scarp of the Sierra Nevada, which rises over 10,000 feet above Owens Valley, and the scarp along the west face of the Black Mountains, which slopes about 35 degrees toward Death Valley, are two of the most prominent fault scarps in the Lahontan Region. The west face of the Panamint Range is a fault scarp characterized by triangular faceting which has been formed by erosion of the scarp by transverse stream drainage. A few of the more important faults, from the standpoint of ground water resources, are discussed in this section.

San Andreas Fault. The southwestern portion of the Lahontan Region is bounded by the San Andreas fault, which extends a distance of about 600 miles from the Gulf of California, northwestward through the Colorado Desert, Transverse Ranges, and Coast Ranges, and thence offshore for an unknown distance northwestward from Point Arena. The San Andreas fault zone comprises many local subparallel faults and in some places is many miles wide. Principal movement along the fault is right-lateral; that is, the northeast side of the fault zone moves southeastward and the southwest side moves northwestward. The course of the fault along and adjacent to the Sierra Pelona and San Gabriel Mountains is clearly defined by valleys, aligned saddles, sag ponds, offset streams, and alignment of springs.

The general features of the San Andreas fault in the Lahontan Region can best be seen in the vicinity of Pearblossom. There the angular unconformity between the flat-lying Pleistocene conglomerate and the underlying steeply dipping sandstone of the Punchbowl formation is well exposed. The main trace of the fault is exposed also at the Palmdale Reservoir, where a south-facing fault scarp has been utilized as a natural dam in constructing the reservoir.

Garlock Fault. From its intersection with the San Andreas fault in the Tehachapi Mountains, the Garlock fault runs northeastward for about 150 miles to the Slate Range. At that point, the fault turns eastward and runs along the north edge of the Granite Mountains to the northern slopes of the Avawatz Mountains. The Garlock fault separates the Basin-Ranges Province and the Mojave Desert Province.

The fault trace is generally straight, steep, and clearly defined. The fault zone is several miles wide, except in a few areas such as the area south of Searles Lake, where it appears as a simple fracture.

Displacement along the fault is mainly left-lateral, but normal faulting has also occurred. From the Slate Range southwestward to Gorman, the block lying northwest of the fault has risen with respect to the southeast block.

Movement of the Garlock fault during Quaternary time effected closure of several valleys and caused modification of the valleys to form interiorly-drained basins. Near the town of Garlock, faulting has displaced a large alluvial fan and formed a prominent fault scarp.

Approximately four miles north of Garlock, large fault blocks have been downdropped to form depressions which clearly mark the fault trace. Numerous springs along the fault trace indicate that the Garlock fault obstructs ground water movement.

Faults East of the Sierra Nevada. Recent fault movement in the Owens Valley has occurred along the fault zone bordering the eastern front of the Sierra Nevada. Nearly all the mountains in this area are of fault block origin.

As previously mentioned, parallelism is noticeable in the arrangement of the mountains and the valleys. This parallelism is most prominent in the Slate and Panamint Ranges which are separated by Panamint Valley, and in the Panamint and Amargosa Ranges which are separated by Death Valley. The valleys are downdropped blocks or grabens, and the mountains are uplifted blocks or horsts. Variations in depths to bedrock in alluviated valleys indicate that tilting has accompanied faulting.

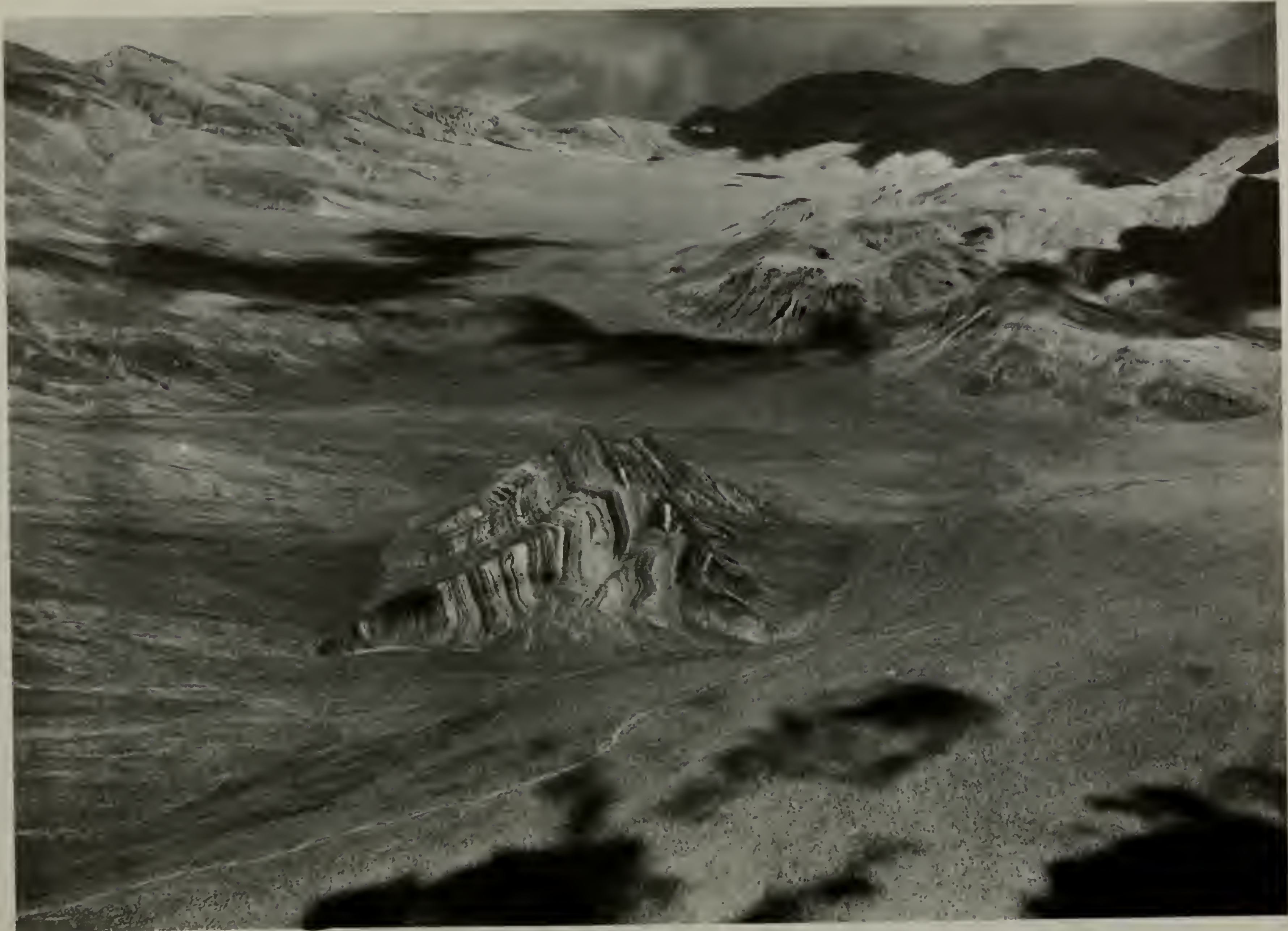
Faults in the Mojave Block. The Mojave Block is a term applied by Hewett (1954) to the part of the Mojave Desert that lies between the San Andreas fault on the southwest and the Garlock fault on the north. Structural features on each side of this block have little similarity to those within the block. Hewett believes that the Mojave Block was involved in the Jurassic and Cretaceous orogenies, and that by middle Miocene time, when the first Tertiary deposits were laid down, this block had been uplifted as much as 20,000 feet in relation to the areas to the north and south of it.

Faulting has divided the Mojave Block into two systems: a northwesterly trending group of faults which are subparallel to the San Andreas fault and a system of faults in the northeastern portion of the Mojave Block which has no dominant trend. Most of the faults which parallel the San Andreas fault generally range in length from 3 miles to 20 miles, some faults as long as 40 miles. Reverse, normal, and scissor faults have been observed in the field. Recent movement is shown by scarps and sag ponds, and abrupt water level variations have been used to determine the location of faults buried by the Recent alluvium.

Folding

In general, geologic materials younger than Pliocene age have not been appreciably affected by folding. Older alluvial material in the basins probably has been downwarped by the large quantities of debris deposited by streams emanating from the surrounding highlands. One of the most prominent folds in the Lahontan Region is an east-west trending syncline north of Barstow. This syncline consists of folded beds of Tertiary age which have also undergone some faulting.

According to Thompson (1929), the folds located by Buwalda (1914) at the east end of the Alvord Mountains, about 20 miles northeast of Barstow, and the eastward trending folds located by Keyes (1910) in the sediments of the old Borate mining district on the east side of the Calico Mountains, may be on the same line of deformation as that which has affected the Tertiary sediments of the Barstow syncline. Folds have also been noted by Thompson (1929) in the Kingston Range, and in the Tertiary sediments of southern Death Valley.



Butte Valley, Panamint Range

Spence Air Photos

The geologic history of the Lahontan Region is extremely complex.

Geologic History

The geologic history of the Lahontan Region is extremely complex, and each of the various geomorphic or physiographic provinces comprising the region is characterized by a distinguishing geologic record. This section summarizes the dominant geologic occurrences in the history of the region.

In Paleozoic time, alternate periods of continental emergence and submergence occurred. That is, areas that were once above sea level were inundated for a period of time, after which the water receded and the areas once more were above sea level. During this time, a major geosyncline or basin existed in the Mojave Desert province. From Middle Cambrian through the Cretaceous, the basin filled with marine sediments. During Jurassic time, the Basin-Ranges province was part of a vast area which underwent structural deformation.

Near the end of the Jurassic, a great batholithic intrusion occurred throughout the region and near the end of this period, or in early Cretaceous time, the Mojave Block and the Transverse Ranges began to be elevated. While the mountain blocks were being elevated to form high upland areas of bold relief, vigorous erosion occurred which eventually resulted in a topography consisting of broad lowlands interrupted by hills and ridges.

During early Tertiary time, the entire region underwent prolonged erosion, accompanied by re-elevation with the Mojave Block continuing to rise well into mid-Tertiary time to a maximum elevation of 15,000 feet. In middle Tertiary time, marine seas covered the western portion of Antelope Valley. Subsequent to the deposition of upper

Tertiary sediments, further deformation occurred in late Tertiary time, accompanied by volcanism, erosion, and sedimentation. Almost all of the Tertiary sediments were faulted and folded. Structural deformation throughout the provinces was not contemporaneous, with some movements beginning earlier and continuing later in some areas than in others.

The volcanism that occurred during Tertiary time was accompanied by the deposition of sediments. As a result, basalt flows are interbedded with tuff, pumice, and alluvial debris to form extensive geologic units.

During Miocene and Pliocene time, a portion of the desert drained to the San Joaquin Valley (Axelrod 1956), and may have drained toward the Los Angeles area. Drainage systems were altered by diastrophism occurring in the late Tertiary when most of the present mountains and valleys were formed.

A study of the Pleistocene history enables geologists to determine the origin of present day drainage systems. Although the various basins and drainage systems were formed by late Pliocene time, heavy precipitation during intervals of Pleistocene glaciation modified the landscape closer to its present form. Aggradation and erosion have continued and have concealed much of the older landscape.

During the Pleistocene, the southwestern portion of the United States, including the Lahontan Region, was subjected to at least four major episodes of glaciation which lasted many thousands of years. These four episodes were interrupted by longer intervals of warm climatic conditions similar to those of the present day. Blackwelder (1931) has termed the most recent of these glacial episodes the Tioga and successively older episodes the Tahoe, Sherwin, and McGee.

According to Blackwelder, the snow line descended to an elevation of 6,000 feet in the Sierra Nevada during Tioga time. Glaciers which formed at higher altitudes moved downward as low as 4,000 feet.

Streams emanating from the Sierra Nevada and other high mountains drained into lowland basins, filling some of these basins to form extensive lakes. As the water from these lakes overflowed, it cut gaps through portions of the shoreline and spilled over into successively lower regions, thus integrating the drainage. The geologic record of the existence of lakes of Tioga age is clearly defined by wave cut terraces, spits, and gravel bars. Where deep trenching through surficial deposits has occurred, as in the narrows of the Mojave River near Afton, the lake sediments are well exposed.

A brief description of the Pleistocene history of the more important areas in the Lahontan Region is given in the following paragraphs.

Death Valley probably contained lakes during all the glacial episodes. It may have received drainage from Owens River on the west, from the Mojave River on the south, and from the Amargosa River on the east. These drainage systems are shown on Diagram 2. The Amargosa River is presently the only major river which flows into Death Valley, with such flow occurring only after heavy precipitation and runoff. During the Tahoe episode, Lake Manly, the largest of the Pleistocene lakes, inundated Death Valley. This lake was about 600 feet deep, 116 miles

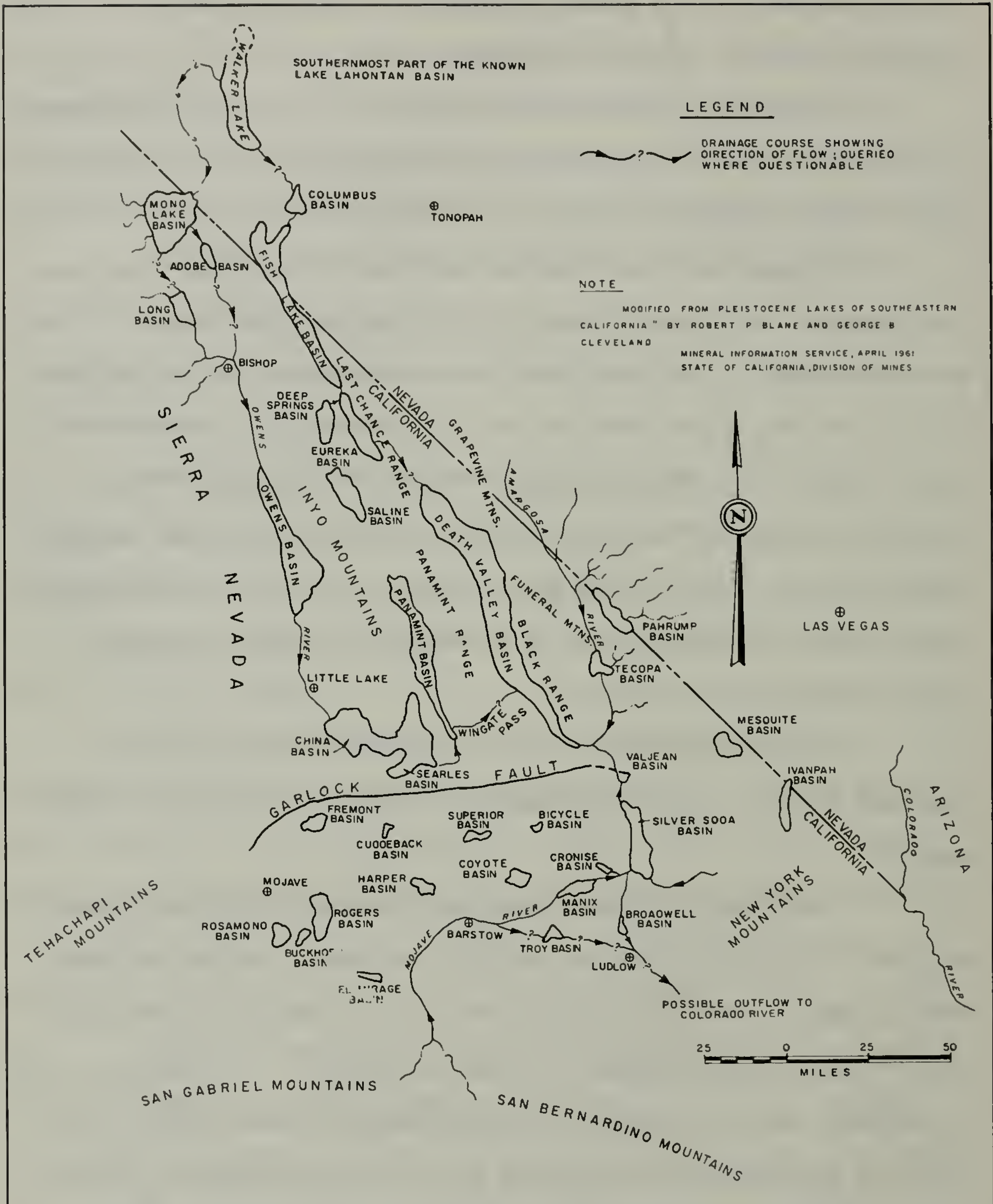


DIAGRAM 2. DRAINAGE OF PLEISTOCENE LAKES IN THE LAHONTAN REGION

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1963 long, and 12 miles wide. Ancient shore lines, gravel bars, and terraces indicate the existence of this great lake.

Small fish which inhabit some of the springs and streams in Death Valley are morphologically similar to fish in the Colorado River. This similarity indicates that a connection probably existed at one time between Death Valley and the Colorado River. Death Valley may have been connected with the Lahontan Region in Nevada by a route along the east side of the Panamint Range. Some scientists believe that Lake Manly in one of its early stages may have overflowed southward and southeastward by way of Ludlow into the Colorado River. As the waters of Lake Manly evaporated, the salts in solution were precipitated to form the saline deposits which are now part of the valley floor.

During periods of glaciation, the Owens River filled the portion of Owens Valley south of Lone Pine and formed Lake Owens, a lake which covered 200 square miles and was 190 feet deep. When this lake overflowed at its south rim, the Owens River cut a notch into the lava flow which now forms the southern periphery of Little Lake. As this ancestral river emerged into Indian Wells Valley, it formed an extensive lake about 100 feet deep, which is presently indicated by the China Lake saline deposits. The stream emanating from Indian Wells Valley cut through a ridge on the east side of the valley, and overflowed into Searles Basin to the east to form Lake Searles. This lake was 375 feet deep and 16 miles long and was formed during the last of the glacial episodes. Although the lake may have had an outlet during earlier stages of glaciation, it had no outlet during the latter stages of glaciation. Evaporation of this lake resulted in the accumulation of thick saline deposits which are now mined for commercial purposes.

This area was occupied at least once by a more extensive system of lakes whose water level was over 600 feet above the present level of China Dry Lake. The China and Searles Basins at that time were covered by one large lake which overflowed to the southeast and then flowed eastward and northward into Panamint Valley. As the flow of water from Owens Valley decreased, overflow to each lower basin was also reduced and the filling of Searles Basin was terminated. Evaporation lowered the level of water in the lake until only a salina remained.

Searles Dry Lake contains an upper crystal body 70 to 80 feet thick which is underlain by an impermeable seam of clay or mud about 12 feet thick. A crystal body that is approximately 35 feet thick underlies the clay. According to Mumford (1954), the upper crystal body was probably deposited following the end of the Tioga episode, about 5,000 years ago. The salt body underlying the clay was deposited following the close of the Tahoe episode. Radioactive age determinations of organic matter from the base of the clay seam indicate that it is about 16,000 years old.

Water flowing from the San Gabriel and San Bernardino Mountains accumulated in many shallow basins, which are now represented by playas. During the last two glacial episodes, an integrated drainage system existed along the course of the Mojave River which may have flowed northward into Death Valley. About 23 miles east of Barstow, the ancient Lake Manix, which was about 200 feet deep, was formed in part by the inflow from the Mojave River. Tectonic activity may also have been a factor in formation of this lake. From Lake Manix, the Mojave River flowed eastward through Afton Canyon to a low area to form ancient Lake Mojave which covered the present Soda and Silver Lake Basins. Part of this flow formed Little Lake Mojave, the present site of Cronise Basin. Lake Mojave was about 40 feet deep. Well preserved shore terraces and gravel bars show that the stream emanating from this lake cut a narrow gorge as it flowed northward from Silver Lake to join the Amargosa River before entering Death Valley.

During earlier Pleistocene time, the Mojave River may have flowed to the east of Newberry Springs and Ludlow to join the Colorado River. The Pisgah Volcano may have diverted the Mojave River to the east and northward into Death Valley in more recent time.

Hanuopoh Canyon

Spence Air Photos

Ground water basins are replenished by surface runoff from the surrounding mountains.

CHAPTER III. WATER SUPPLY AND UTILIZATION

The vast reaches of arid and semiarid lands in the Lahontan Region have yielded to cultural development by man only in those areas of the region where firm supplies of usable water have been available. With adequate water supplies, agricultural, urban, and industrial developments have been established and sustained. However, where the supply has diminished in quantity or declined in quality, these developments have waned, and in some instances have entirely disappeared.

A general discussion of the nature and source of the water supply in the Lahontan Region is presented in this chapter. The geologic and hydrologic factors affecting the occurrence and stability of the supply are discussed, as are the historical and present development of the supply and the various purposes for which the supply has been utilized.

Water Supply

The principal sources of water supply in the Lahontan Region are precipitation, surface runoff, and ground water. The amounts contributed to the supply by each of these items vary considerably in various portions of the region. This section discusses the contributions of these items to the supply, with particular emphasis on the contribution and role played by ground water in the region.

Precipitation

Precipitation, and the resulting surface runoff, is the major source of replenishment to the ground water basins in the Lahontan Region. In most of the low desert areas, precipitation usually occurs as rainfall but at the higher elevations, snowfall is common during the winter months.

The maximum and minimum, and mean seasonal amounts of precipitation for the period of record, at selected stations in the Lahontan Region, are shown on Table 3. The location of these stations, and isohyetal lines are shown on Plate 2, "Geographic Distribution of Precipitation."

As shown on Table 3, the mean seasonal amount of precipitation varies widely in the region, ranging from 1.69 inches at Greenland Ranch in the Furnace Creek area, to 45.14 inches at Lake Arrowhead in the San Bernardino Mountains. About 75 percent of the mean seasonal precipitation occurs during the winter and early spring months, November through April. However, local thunderstorms occurring at random intervals in the summer months have occasionally contributed more than the mean seasonal amount to local areas in less than two hours.

Precipitation characteristics within the individual basins of the Lahontan Region are discussed in Chapter V.

Surface Runoff

Surface runoff in the Lahontan Region usually results from rainfall, the melting of the snowpack on the surrounding mountains, or from other sources such as springs. This runoff is drained to one of the three major stream systems by an integrated network of perennial, intermittent, and ephemeral streams, or is drained internally to playas and other topographical lows within the basins.

The three major stream systems in the Lahontan Region are the Mojave River system, which drains the southwestern portion of the region; the Owens River system, which drains the northwestern portion of the

TABLE 3

MEAN, MAXIMUM, AND MINIMUM SEASONAL PRECIPITATION AT SELECTED STATIONS IN LAHONTAN REGION

Name of station	County	Latitude and longitude	Elevation, in feet	Period of record	Type and source of record*	Mean seasonal precipitation: Period of record, in inches	Mean seasonal precipitation: 1897-1947 period**, in inches	Maximum and minimum seasonal precipitation: Season	Maximum and minimum seasonal precipitation: Inches
Alabama Hills	Inyo	36° 40' 118° 06'	3,790	1922-23 1946-47	BD DWR	3.50	3.52	1940-41 1922-23	6.93 0.42
Big Pines Power Plant No. 3	Inyo	37° 07' 118° 19'	5,200	1926-27 1958-59	B LADWP	8.61	8.16	1937-38 1930-31	17.99 1.55
Bishop	Inyo	37° 22' 118° 22'	4,450	1884-85 1958-59	BC USWB	6.13	6.14	1951-52 1947-48	13.52 1.55
Cottonwood Gates (Near Owens Lake)	Inyo	36° 25' 118° 02'	3,600	1924-25 1958-59	B LADWP	5.60	5.54	1940-41 1924-25	11.08 1.59
Deep Springs School	Inyo	37° 22' 117° 59'	5,225	1956-57 1960-61	B USWB	5.31	--	1957-58 1959-60	9.71 2.46
Greenland Ranch (Furnace Creek)	Inyo	36° 27' 116° 52'	- 178	1911-12 1946-47	BC USWB	1.69	1.61	1938-39 1918-19	4.52 0.03
Haiwee	Inyo	36° 08' 117° 58'	3,800	1923-24 1946-47	B USWB	6.20	5.96	1940-41 1932-33	15.36 1.77
Independence	Inyo	36° 48' 118° 12'	3,944	1866-67 1958-59	ABC USWB	4.92	4.68	1867-68 1947-48	20.28 0.80
Keeler	Inyo	36° 29' 117° 52'	3,622	1885-86 1908-09	BC USWB	3.01	2.83	1904-05 1897-98	8.60 0.53
Lake Sabrina	Inyo	37° 13' 118° 36'	9,100	1909-10 thru 1947-48 1949-50 1951-52 thru 1957-58	BD USWB	17.02	16.10	1937-38 1912-13	33.97 8.63
Little Lake	Inyo	35° 56' 117° 54'	3,580	1928-29 1937-38	B LADWP	5.80	5.96	1936-37 1928-29	9.80 2.51
Lone Pine	Inyo	36° 36' 118° 04'	3,728	1904-05 1937-38	BC USWB	4.98	4.30	1916-17 1933-34	8.04 1.00
Mojave	Kern	35° 03' 118° 10'	2,751	1876-77 1946-47	BC LADWP	5.16	4.93	1943-44 1882-83	14.13 Trace
Bodie	Mono	38° 13' 119° 02'	8,240	1895-96 1905-06	BC USWB	14.58	13.03	1900-01 1902-03	21.45 9.12

TABLE 3

MEAN, MAXIMUM, AND MINIMUM SEASONAL PRECIPITATION AT SELECTED STATIONS IN LAHONTAN REGION
(continued)

Name of station	County	Latitude and longitude	Elevation, in feet	Period of record	Type and source of record*	Mean seasonal precipitation: Period of record, in inches	Mean seasonal precipitation: 1897-1947 period**, in inches	Maximum and minimum seasonal precipitation: Season	Maximum and minimum seasonal precipitation: Inches
Ellery Lake	Mono	37° 56' 119° 14'	9,600	1925-26 1958-59	BD USWB LADWP	25.55	31.69	1926-27 1947-48	40.83 13.40
Gem Lake	Mono	37° 45' 119° 08'	9,120	1919-20 1958-59	BD USWB LADWP	23.93	26.74	1919-20 1949-50	44.25 11.66
Long Valley Reservoir (Lake Crowley)	Mono	37° 34' 118° 43'	6,700	1920-21 1958-59	D LADWP	9.71	9.95	1937-38 1923-24	20.09 3.69
Lundy Lake	Mono	38° 02' 119° 13'	7,760	1919-20 1939-40	BD USWB	15.60	14.99	1937-38 1930-31	33.80 7.91
Fairmont (near)	Los Angeles	34° 43' 118° 26'	3,036	1909-10 1946-47	B USWB	15.21	14.28	1940-41 1924-25	29.13 5.70
Lancaster High School	Los Angeles	34° 42' 118° 08'	2,350	1930-31 1946-47	CD LAFC	8.65	7.01	1940-41 1935-36	17.48 4.03
Little Rock Creek	Los Angeles	34° 30' 118° 02'	3,035	1929-30 1946-47	CD LAFC	11.17	9.17	1943-44 1933-34	20.08 4.39
Llano	Los Angeles	34° 30' 117° 47'	3,400	1916-17 1946-47	B USWB	7.79	7.63	1943-44 1933-34	19.02 2.12
Palmdale	Los Angeles	34° 34' 118° 07'	2,660	1932-33 1946-47	B USWB	10.09	8.37	1940-41 1933-34	18.41 5.64
Vallyermo	Los Angeles	34° 27' 117° 52'	3,740	1911-12 1946-47	BCD LAFC	11.16	10.62	1940-41 1922-23	21.22 4.81
Barstow	San Bernardino	34° 54' 117° 02'	2,105	1889-90 1946-47	BC USWB	4.50	4.17	1940-41 1895-96	8.67 0.67
Daggett Airport	San Bernardino	34° 52' 116° 48'	1,922	1956-57 1960-61	B USWB	3.60	--	1957-58 1956-57	5.21 2.00
Dunn Siding	San Bernardino	35° 03' 116° 27'	1,625	1959-60 1960-61	B USWB	2.98	--	1960-61 1959-60	3.11 2.85
Forks of Mojave	San Bernardino	34° 21' 117° 14'	3,000	1905-06 1919-20	B Private	13.02	13.28	1906-07 1912-13	25.77 6.84

TABLE 3

MEAN, MAXIMUM, AND MINIMUM SEASONAL PRECIPITATION AT SELECTED STATIONS IN LAHONTAN REGION
(continued)

Name of station	County	Latitude and longitude	Elevation, in feet	Period of record	Type and source of record*	Mean seasonal precipitation		Maximum and minimum seasonal precipitation	
						Period of record, in inches	1897-1947 period** in inches	Season	Inches
Hesperia	San Bernardino	34° 25' 117° 18'	3,200	1904-05 1914-15	B Private	8.55	8.33	1906-07 1912-13	13.94 3.19
Kingston	San Bernardino	35° 45' 115° 40'	2,475	1925-26 1941-42	B USWB	4.18	4.05	1931-32 1925-26	8.31 0.69
Lake Arrowhead	San Bernardino	34° 15' 117° 12'	5,100	1928-29 1946-47	D DWR	45.14	43.70	1937-38 1930-31	79.27 21.06
Mountain Pass	San Bernardino	35° 28' 115° 32'	4,735	1956-57 1960-61	B USWB	7.37	--	1957-58 1960-61	11.17 4.86
Silver Lake	San Bernardino	35° 23' 116° 06'	1,045	1956-57 1960-61	B USWB	2.78	--	1957-58 1959-60	4.72 1.99
Trona	San Bernardino	35° 45' 117° 22'	1,656	1920-21 1946-47	B USWB	4.40	4.13	1940-41 1924-25	11.47 1.85
Victorville	San Bernardino	34° 32' 117° 18'	2,840	1904-05 1946-47	AB USWB	6.02	5.48	1940-41 1912-13	12.35 1.63
Yucca Grove	San Bernardino	35° 23' 115° 52'	3,951	1931-32 1946-47	B USWB	7.57	6.94	1940-41 1933-34	11.89 1.88

* Type of Record
- A Hourly
- B Daily
- C Monthly
- D Seasonal

* Source of Record
- LADWP - Los Angeles Department of Water and Power
- USWB - United States Weather Bureau

** Computed mean seasonal precipitation for period 1897-1947 as presented in Table 66 of Water Resources Board Bulletin No. 1.

Mojave River at Barstow, 1938 — Spence Air Photos

Surface flows in the Mojave River vary greatly.

region; and the Amargosa River system, which originates in Nevada and drains the northeastern portion of the region.

The Mojave River, whose headwaters drain almost the entire northern slopes of the San Bernardino Mountains, extends northeasterly from those mountains about 100 miles, terminating in Soda Lake near Baker. Deep Creek and the West Fork of the river are the two largest tributaries of the river, and both of these tributaries are usually perennial in their upper reaches in the mountains.

At lower elevations, the surface flow in the Mojave River usually percolates rapidly, except during periods of heavy flow, and much of the lower course of the river consists of dry channels. However, rising water appears as surface flow in the river's channel near Victorville and Afton, even during dry periods. Table 4 indicates the amounts of seasonal runoff, measured at the United States Geological Survey gaging stations at Victorville, and at Barstow, about 38 miles downstream. The wide variation in the amount of surface flow at these two stations is due to percolation and other losses.

The Owens River originates on the eastern slope of the Sierra Nevada and flows southeasterly towards Owens Lake; it is the major stream in the northwestern portion of the Lahontan Region. Most of the tributaries of the Owens River are quite short. Fed principally by the melting of the snowpack in the Sierra Nevada, the tributaries flow easterly down the steep flank of these mountains.

The flow of the Owens River has been regulated to a great extent by a series of dams and reservoirs which have been constructed along the river's course for water supply and power developments. The Department of

TABLE 4

SEASONAL RUNOFF OF THE MOJAVE RIVER
AT VICTORVILLE AND BARSTOW

(In acre-feet)

Season	Victorville (Lower Narrows)	Barstow
1935-36	20,420*	0
1936-37	150,200	103,900
1937-38	188,100	138,100
1938-39	29,680	550
1939-40	27,480	0
1940-41	143,300	96,000
1941-42	25,790	101
1942-43	127,300	90,980
1943-44	77,650	36,260
1944-45	54,640	22,090
1945-46	43,210	12,570
1946-47	37,200	2,880
1947-48	26,310	0
1948-49	22,840	0
1949-50	21,630	0
1950-51	20,820	0
1951-52	66,790	12,540
1952-53	21,800	0
1953-54	31,230	0
1954-55	22,520	0
1955-56	21,740	0
1956-57	20,560	0
1957-58	98,040	20,070
1958-59	20,320	0
1959-60	19,270	0
1960-61	18,910	0

* Flow measured at Upper Narrows for 1935-36, and at Lower Narrows thereafter.

Water and Power of the City of Los Angeles has established dams, reservoirs, and powerplants along the Owens River Gorge, and in Long Valley and Pleasant Valley. The City of Los Angeles has also constructed an aqueduct system and has diverted water from the river above Owens Lake since 1913; this diversion has caused Owens Lake to become essentially a dry lake bed, and since 1928, flow from the river has reached Owens Lake only in insignificant quantities.

The estimated mean seasonal natural runoff in the Owens River, and in other streams in the Owens River Drainage Basin and the Mono Lake Drainage Basin, for the period 1894-95 through 1958-59, is shown on Table 5.

The Amargosa River originates in Nevada and flows southward across the California-Nevada border near Death Valley Junction, following an irregular course towards the Avawatz Mountains. Near the northern base of these mountains, the river makes a sweeping turn northward toward Death Valley where it terminates at Badwater at an elevation of 292 feet below sea level. The Amargosa River drains the portion of the Lahontan Region where little cultural development has occurred.

Surface flows in the Amargosa River are infrequent; however, in response to heavy local rainfall, flows have occurred in the river's channels as far downstream as Death Valley.

Imported Water

The use of imported water has been an insignificant factor in the historical development of the Lahontan Region but its use will undoubtedly be required to support the region's growth in the foreseeable future.

TABLE 5

ESTIMATED MEAN SEASONAL NATURAL RUNOFF IN THE OWENS RIVER AND MONO LAKE DRAINAGE BASINS

(In acre-feet)

Drainage Basin and Streams	Period 1894-95 through 1958-59	
Owens River Drainage Basin (No. 14)		
Owens River above gage near Round Valley	156,800	
Rock Creek above gage near Little Round Valley	26,300	
Remainder of Owens River above Tinemaha Reservoir	208,400	
Subtotal - Owens River above Tinemaha Reservoir	391,500	
Remainder of Owens River	118,500	
Total - Drainage Basin		510,000
Mono Lake Drainage Basin (No. 11)		
Walker Creek at Walker Lake	5,220	
Rush Creek below Silver Lake	61,440	
Parker Creek below Parker Lake	8,130	
Leevining Creek at Power Plant No. 3	48,280	
Mill Creek at Lundy Lake	21,230	
Remainder of East Sierra drainage	45,500	
Subtotal - East Sierra drainage to Mono Lake	189,800	
Remainder of Mono Basin	26,200	
Total - Drainage Basin		216,000
TOTAL		726,000

Thus far, the amounts imported have been negligible, and they have been derived from limited sources of supply. For example, small quantities of water have been diverted from Virginia Creek, a tributary of the Walker River, and have been imported for use in the Mono Lake Valley Ground Water Basin in the northern portion of the region. In another instance, where ground water basins in the Lahontan Region extend across the border into Nevada, wells in the Nevada portion of these basins supply water for irrigation and domestic uses in the California portions.

Ground Water

Although surface water and imported water have been used at a few points in the Lahontan Region, ground water has been the most important source of water supply in the developed portions of the region. The quantities of ground water available at various locations in the region are dependent upon the nature of the underlying geologic materials and the hydrologic characteristics of the ground water basins.

Occurrence and Movement. The principal source of ground water in the Lahontan Region is the unconsolidated alluvial sediments. As described in Chapter II, these sediments cover the floors of the ground water basins in the region, ranging in thickness from a few feet to more than 500 feet. The crystalline rocks which surround and underlie most of the ground water basins are also a source of ground water, but quantities produced are markedly less in these rocks than in the alluvium. Deep weathering of these crystalline rocks has formed layers of decomposed materials; in some portions of the Lahontan Region the ground water stored in such material is the sole source of water supply.

The ground water basins in the Lahontan Region are replenished by deep percolation of precipitation and surface water, by unconsumed portions of applied irrigation water, and by subsurface inflow from adjacent ground water basins. During infrequent wet periods, precipitation and surface runoff from surrounding highlands percolate into rock joints and fissures of the crystalline rocks, and into the alluvium on the valley floors, replenishing the ground water supply.

The portion of water which is applied to irrigated crops but not consumptively used or evaporated percolates to the underlying materials, thereby replenishing the ground water supply. However, irrigated agriculture development has been confined to a few relatively small areas in the Lahontan Region and replenishment from this source has been in limited quantities.

Subsurface inflow of ground water to basins within the Lahontan Region from ground water basins in surrounding areas occurs at several points. The most substantial amounts of such inflow enter the region in those ground water basins which estend from the region across the California-Nevada border. Small amounts of subsurface inflow also occur across the Mono drainage divide on the north, and across the Colorado Region drainage divide in an area south of Barstow.

Ground water movement is affected by the permeability of the rock materials, their geologic structure, the hydraulic gradient, and other factors. In the crystalline rocks of the highlands which surround most of the basins in the Lahontan Region, ground water moves very slowly through the joints and fissures and layers of weathered materials; the direction of flow is toward the valley floor. Little or no deep percolation occurs in these relatively impermeable rocks. The alluvial material on the valley floors of most of the ground water basins in the region is more permeable; ground water in this material moves more rapidly and percolates readily. However, replenishment of the ground water supply via this material usually occurs only during infrequent wet periods when large quantities of surface runoff flow down from the surrounding highlands.

Ground water movement within the basins is in the direction of the hydraulic gradient. In basins that drain internally, this gradient usually slopes towards the lowest portion of the basin. In basins forming integrated drainage systems, the gradient usually slopes from the basins at the higher elevations to those at the lower elevations. At the same time, the slope of the hydraulic gradient and a consequent change in the direction and rate of ground water movement may be affected by naturally occurring barriers such as faults, or by the works of man such as where extractions of ground water by wells produce pumping depressions. Such changes also affect ground water levels within the various basins, as will be discussed in greater detail in the next section.

Ground Water Levels. The depth to ground water from the surface, or elevation of the ground water table, is of economic and hydrologic significance in the water supply and development of an area.

Economically, where ground water levels are near the surface, the use of ground water as the major source of supply is enhanced because of decreased pumping lifts and greater freedom in selection of well locations. On the other hand, ground water levels at or near the surface may result in a depletion of the supply through loss by evapo-transpiration by native vegetation, evaporation of ground water brought to the surface by the capillary action of the soil, and evaporation of surface flow from springs, particularly where the flow is onto a playa lake.

In the Lahontan Region, ground water levels range widely in elevation, not only from basin to basin, but within the individual basins as well. In many of the basins the water table may be a few feet below the surface of the ground, but along the higher elevations it may be several hundred feet below the surface.

As mentioned earlier, water levels may be significantly affected by faults and other geologic features. Faults may act as barriers to the movement of ground water; often there are significant variations in the elevations of ground water levels on opposite sides of a fault. In addition, where deeper aquifers are confined by impermeable geologic structures, water levels in wells perforating such confined aquifers may rise to higher elevations than in wells perforating shallower, unconfined aquifers.

Ground water levels have generally declined in those portions of the Lahontan Region which are most highly developed, such as the Antelope Valley Ground Water Basin (6-44). At some points in this basin, ground water levels have declined as much as 150 feet over the last 30 years. In other portions of the region where only slight development has occurred, ground water levels have remained practically unchanged, or have declined slightly.

Data on historic ground water levels for the individual basins in the Lahontan Region are presented in Chapter 5. When considering these data, the factors discussed in this section should be given due regard.

Water Supply Development

The development of ground water supplies in the Lahontan Region has far exceeded that of any other source of supply, including surface diversions and imported water. Although surface diversions have been and are being made in the region, primarily for irrigated agriculture, such diversions constitute a relatively insignificant portion of the total water use in the region. The development of surface water supplies for export to the City of Los Angeles is discussed in Chapter V.

Ground Water Development. Prior to 1900, ground water development in the Lahontan Region was limited to a few hand-dug pits or shallow wells, usually in the vicinity of rivers or flowing streams where water was readily obtainable near the surface. After 1900, drilling techniques and pumping equipment improved, permitting larger quantities of ground water to be used in an increasing number of basins in the region.

The introduction of electric power to many of the developed portions of the region after 1914 permitted a considerable increase in the acreages devoted to irrigated agriculture in some of the basins. However, declining ground water levels in several of these basins in the last few years have been followed by decreased agricultural acreages.

The development of ground water supplies in the Lahontan Region has been carried out primarily by individuals rather than by organized agencies, and the majority of the irrigated agriculture acreages are served by individually owned wells.

Yield of Wells. The number of wells and pumping plants of heavy draft in the Lahontan Region in 1961 was estimated to be on the order of several thousand, and an equivalent number of light draft wells was estimated to be in service supplying limited amounts of water for non-commercial gardens and orchards, and other domestic, municipal, and industrial uses. The location of wells in the various basins of the region and data on the quality of water in the wells are presented in Chapter V.

The yield of a well depends largely on the type of material penetrated by the well. Wells drilled in the older formations or in the crystalline rocks that surround or underlie the ground water basins of the region generally yield less than 100 gallons per minute; very often such wells yield only a few gallons per minute. On the other hand, wells in the coarser alluvium on the valley floors may produce as high as 4,000 gallons per minute. In areas of a basin where the well has been drilled or dug in finer-grained alluvial material the yield is much lower. In several cases, old irrigation wells, usually hand-dug, were found with very large diameters providing storage space for the slow subsurface inflow that occurs in such material.

In recent times, within the last decade or so, a great many smaller wells have been drilled and are serving the domestic needs arising from the population influx to the area, particularly in those portions of the region where larger farms and acreages have been subdivided into lots of five acres or smaller. Most of these newer wells are eight inches in diameter, drilled by the cable-tool method, and are not gravel packed. Thus, in most instances, they are adequate only for supplying an individual family with their domestic water requirements.

Water Utilization

The primary use of water in the Lahontan Region is in the irrigation of agricultural crops. In the past, domestic and industrial uses have been relatively small in comparison with agricultural uses. However, expanding urban centers and the establishment of new industrial and military facilities in the region, particularly in the southern portion, will undoubtedly increase the quantities used by these non-agricultural activities.

Under present conditions of development, about 114,000 acres of land in the Lahontan Region, or about two percent of the total valley-mesa lands in the region, are utilized for irrigated agriculture. Nearly 90 percent of the 450,000 acre-feet of water consumptively used in the Lahontan Region annually is consumed in these agricultural uses. Crops include alfalfa, hay, grain, produce, and pasture for livestock.

Although the lack of firm water supplies has limited irrigated agricultural acreages to a few highly developed areas of the Lahontan Region, new sources of supply (either imported or developed locally) would enable and expansion of agricultural acreages. Such additional firm supplies would also permit expansion of urban centers, and industrial installations.

Palmdale Reservoir

Spence Air Photos

Water in the Lahontan Region is used for domestic, municipal, and irrigation purposes.

CHAPTER IV. WATER QUALITY

The objectives of the water quality studies carried out during this investigation were: (a) to determine the quality of water from representative water supply sources in the various basins of the Lahontan Region; (b) to determine the existing beneficial uses of water from these sources; (c) to evaluate and classify the water quality-water use relationships existing in the region; and (d) to identify existing water quality problems, and establish a basis for discerning water quality trends in the region's water supplies.

Water quality concepts, criteria, and standards used to develop water quality use ratings for the Lahontan Region are discussed in this chapter. Detailed information on the quality of water in the individual ground water basins is included in Chapter V. The general discussion of water quality includes information on dissolved constituents in ground water, sources of impairment of ground water quality, and the formulation of water quality use ratings.

Dissolved Constituents in Water

Most naturally occurring waters contain some dissolved minerals. The inherent quality characteristics are mainly correlated with climate and the enveloping geologic complex. Water containing the smallest amounts of dissolved minerals usually is found in areas having the greatest amount of precipitation, particularly where such areas are underlain by igneous rock materials. The kinds and amounts of minerals in the water are governed by the types of rock materials and soils with which the water comes into contact and generally, rainfall governs the concentration of minerals in the water by the mechanism of dilution.

Relatively large amounts of minerals are contained in waters from supplies in areas characterized by one or more of the following features: low precipitation, interior drainage, poorly consolidated deposits of marine origin, and fault zones, through which mineralized waters flow into ground water basins.

The mineral constituents commonly occurring in the ground waters of the Lahontan Region and their role in water quality problems are discussed in the following subsections.

Calcium (Ca)

Calcium can be dissolved from most rocks, but the highest concentrations of calcium are usually in ground waters that have flowed through limestone, dolomite, and gypsum rocks. For irrigation purposes calcium should comprise a high percentage of the cations in order that the irrigated soil be arable and permeable. In contrast, calcium should not be present in high concentrations in water used for domestic and industrial purposes, because it is the principal cause of hardness and formation of scale in boilers and in water pipes. Calcium also reacts with soap, producing a grey scum which inhibits lathering.

Magnesium (Mg)

Magnesium is dissolved primarily from dolomitic rocks and from marine deposits. Magnesium increases the hardness of the water and the scale-forming properties in the same manner as does calcium.

Dissolved magnesium produces another effect; water containing about 125 parts per million of magnesium and about 500 parts per million of sulfate may produce a noticeable laxative effect in persons unaccustomed to these concentrations in their regular drinking water.

Sodium (Na) and Potassium (K)

Sodium and potassium are dissolved from almost all rocks. Ground water supplies that have very low concentrations of total dissolved solids usually contain about equal amounts of potassium and sodium. However, as the concentrations of these and other constituents increase, the proportion of sodium generally becomes much greater.

Moderate quantities of sodium and potassium generally have only a small effect on the usefulness of water. However, industrial use of water containing moderately high concentrations of sodium and potassium in combination with alkalinity, may require that steam boilers be carefully operated to prevent foaming. Water containing sodium or potassium in combination with carbonate also causes corrosion in boiler tubes, condensate lines, and hot water systems.

For laundry and cleaning purposes, it is desirable that sodium make up a high percentage of the cations, since calcium and magnesium cause formation of soapy scums in household washing and deposition of scale in hot water pipes.

For irrigation use, water should have a low ratio of sodium to total cations. High sodium ratio waters reduce soil permeability and reduce or prevent penetration of water to the plant root zone.

Carbonate (CO_3) and Bicarbonate (HCO_3)

Carbonate and bicarbonate are derived from dolomite, limestone, and to a lesser extent from other rocks and minerals. The relative concentrations of these two constituents affect the alkalinity or acidity (pH) of the water. The bicarbonate anion is normally the predominant acid rad-radical in much of the ground and surface water supplies in the Lahontan Region.

Sulfate (SO_4)

Sulfate is dissolved by ground and surface water from many types of rocks and soils. One of the most important sources of sulfate in water is gypsiferous deposits. Sulfate is particularly significant in ground water that contains large concentrations of calcium and magnesium. In combination with calcium and magnesium, sulfate forms deposits of hard scale in water pipes, water heaters and boilers. In combination with magnesium, sulfate may produce laxative effects. In combination with magnesium and sodium, but in the absence of sufficient calcium to precipitate it from soil solution, sulfate may also be present in concentrations that are injurious to plants.

Chloride (Cl)

Most ground waters contain chloride, as it is present in many rock types and is very soluble in water. All waters in the study area contain chloride that has been dissolved from rocks and from natural salt deposits. Disposal of sewage and industrial wastes often introduces large amounts of chloride into ground and surface waters and into the ground water basins. High concentrations of chloride render water unusable for drinking and for processing of foods and beverages. For irrigation use, ground water containing high chloride concentrations is undesirable, because chloride causes subnormal growth of crops and burns the foliage, impairing the appearance and reducing the quality of the marketable crop.

Nitrate (NO_3)

Nitrate generally occurs only in trace quantities in nonpolluted surface water supplies, but may attain high levels in some ground waters. Nitrates that occur in ground water in amounts exceeding a few parts per million are usually dissolved evaporites, fertilizer losses in soil percolates, or by-products of organic decomposition. In addition, large quantities of nitrate are also derived from some magmatic sources, and fixation of nitrogen by bacteria and dissolution of nitrogen from the air by rainfall and subsequent oxidation often produces nitrates in the soil. In excessive amounts (44 parts per million or more) nitrate can cause the illness known as infant methemoglobinemia (cyanosis).

Boron (B)

Boron usually occurs in ground water in the form of boric acid or as a borate. In regions that are or have been volcanic, the borate form is more prevalent. Although boron is widely distributed, the principal deposits are found in the Lahontan Region.

The presence of boron in waters, wastes, and sewage effluents used in agriculture is important. Boron in excess of 2.0 parts per million in irrigation water is deleterious to many plants, and some plants are adversely affected by concentrations of less than 1.0 part per million. However, trace amounts of boron are essential to the growth of other plants.

Electrical Conductivity ($ECx10^6$ at 25° C)

Electrical conductivity is expressed in micromhos at 25° C. Determination of conductivity is a quick method for measuring the ion concentration of a solution. Electrical conductivity is used as an indication of the total dissolved solids content of water.

Total Dissolved Solids (TDS)

Determination of the concentration of total dissolved solids in water furnishes an indication of the overall mineral content of the water and serves as a valuable criterion for appraising the mineral quality of ground water for beneficial uses.

For irrigation use, waters are classified according to total dissolved solids content, which may be determined approximately by electrical conductivity. For most waters, multiplication of the conductivity by a factor of 0.7 gives a number that approximates the total dissolved solids content; this number is nearly equal to the value in parts per million that would be obtained if total dissolved solids content were determined by evaporation.

Radioactivity

The United States Public Health Service defines radioactivity as ionizing radiation that is harmful to the human body. Mankind has always been exposed to natural and background radiation. Any increase of radiation in the water supply above background could be a hazard to the public health.

The most common unit of measurement is the "curie"; however, the term "picocurie" per liter (pc/l) of water is used in this report. A picocurie is equal to a micro-microcurie (uuc) which is a millionth of a millionth of a curie, or approximately 2.22 disintegrations per minute. Naturally occurring radioactive concentrations in surface waters are very low, varying from about 0.10 to 10 picocurie per liter.

The following limits on radioactivity are taken from the Federal Register, Title 42 - Public Health, dated March 6, 1962, and are given here as a guide to the reader for the purpose of evaluating the radioactivity results given in Chapter V.

> "Limits. (1) The effects of human radiation exposure are viewed as harmful and any unnecessary exposure to ionizing radiation should be avoided. Approval of water supplies containing radioactive materials shall be based upon the judgment that the radioactivity intake from such water supplies when added to that from all other sources is not likely to result in an intake greater than the radiation protection guidance recommended by the Federal Radiation Council and approved by the President. Water supplies shall be approved without further consideration of other sources of radioactivity intake of Radium-226 and Strontium-90 when the water contains these substances in amounts not exceeding 3 and 10 uuc/liter, respectively. When these concentrations are exceeded, a water supply shall be approved by the certifying authority if surveillance of total intakes of radioactivity from all sources indicates that such intakes are within the limits recommended by the Federal Radiation Council for control action.
>
> (2) In the known absence of Strontium-90 and alpha emitters, the water supply is acceptable when the gross beta concentrations do not exceed 1,000 uuc/liter. Gross beta concentrations in excess of 1,000 uuc/liter shall be grounds for rejection of supply except when more complete analyses indicate that concentrations of nuclides are not likely to cause exposures greater than the Radiation Protection Guides as approved by the President on recommendation of the Federal Radiation Council."

Sources of Impairment of Ground Water Quality

Natural degradation of water quality from multiple sources and causes has existed for many years prior to man's development of the water and other resources. For example, the rocks and soils comprising the drainage area of a stream system determine the mineral character and quality of the stream's waters. Moreover, highly mineralized tributary springs and saline inland water bodies increase the mineral content of the recipient streams and, consequently, that of the recharged ground water supply.

In the Lahontan Region, continuing studies of ground water by federal, state, and local public agencies have brought into focus many of the sources of impairment of ground water quality. A major factor in the impairment of quality of ground water has been the declining ground water levels resulting from heavy extractions of ground water and the consequent overdraft of some ground water basins. Degradation of the quality of ground water is also caused by upward or lateral movement of poor quality connate waters; by interchange of waters of differing mineral quality between aquifers through improperly constructed or destroyed wells; by downward movement of perched waters of poor mineral quality; and by development of adverse salt balance.

Upward or Lateral Movement of Brackish or Saline Connate Waters by Natural Means

Local areas of very poor quality water occur throughout the Lahontan Region. Large bodies of poor quality connate water occur at relatively great depths in many basins in the Lahontan Region. These poor quality connate waters originated when prehistoric basins were inundated by ocean water. Ocean water that was held in the interstices of sedimentary deposits and sealed in by deposition of overlying beds, frequently appears in water pumped from deep wells, or in water pumped from wells in basins where overdraft has caused fresh water levels to decline to such an extent that connate waters have intruded the fresh water-bearing sediments.

Often these brackish or saline connate waters, which are sodium-chloride type waters, migrate and impair the quality of ground water in fresh water-bearing strata which they underlie or flank. Such intrusion and degradation are most prevalent in ground water basins where extractions have produced overdraft and lowered water levels. As fresh water levels are lowered in a basin, hydraulic gradients are set up which allow connate waters to migrate laterally or upward into adjacent fresh water-bearing sediments. Joints, fractures, faults, and imperfections in confining silt and clay members provide the conduits for migration of the connate waters. Improperly constructed or improperly destroyed wells also provide paths for saline water intrusion of fresh water-bearing strata.

Interchange of Waters of Differing Mineral Characteristics Between Water-Bearing Strata by Artificial Means

Imperfections in confining silt and clay bodies and improperly constructed or destroyed wells allow free flow of water from one water-bearing zone to another, creating problems with respect to existing or potential degradation of the water resources. Interzonal flow of ground water is most serious in areas underlain by several distinct aquifers, each yielding water under a different pressure level and of differing quality characteristics. Under the pressure differential, water of inferior quality may intrude adjacent strata containing water of good mineral quality.

Downward Movement of Perched Waters of Poor Mineral Quality

Perched ground water commonly overlies the confining clay strata of pressure aquifers in portions of many ground water basins in the Lahontan Region. This water accumulates soil solubles and fertilizer chemicals and through evaporation and transpiration, may attain higher salt concentrations than ocean water. Defective, improperly constructed and destroyed wells, and imperfections in confining silt and clay members permit downward movement of this inferior quality perched water into underlying aquifers containing fresh water. Downward migration of the perched water is increased by declining pressure levels, due to increased pumping and overdraft.

Antelape Valley, near Palmdale

Spence Air Photos

Multiple use and reuse of ground water increases the danger of adverse salt balance.

Degradation of well water supplies by percolating perched water is most severe in areas where inferior quality perched waters drain into improperly constructed, or destroyed wells that form a conduit between aquifers.

Development of Adverse Salt Balance

Impairment of quality of ground water is long-lasting and may be permanent if there is no drainage from the ground water basin. Degradation of water quality is further accentuated by adverse salt balance. Adverse salt balance is most pronounced in areas of overdraft where the water supplies to the basin are used extensively and in areas where no ground water moves from the basin. In these areas, salinity builds up over a period of years, rendering the ground water increasingly less suitable for beneficial uses.

Multiple use and reuse of ground water increase the danger of adverse salt balance. Percolation of dissolved fertilizers and industrial wastes increases the mineral burden of the water and decreases the possibility of restoring a favorable salt balance. Adverse salt balance in ground waters is in marked contrast to adverse salt balance in surface streams. In surface streams impairment of water quality may be alleviated by flood flows or corrected by discontinuance of specific waste disposals.

Adverse salt balance becomes most pronounced in ground water basins where a continual condition of overdraft exists and where there is little or no movement of ground water from or into the basin. In these areas, the salinity caused by even relatively innocuous wastes may build up dangerously over a period of years, thus rendering the ground waters increasingly less suitable for beneficial uses.

Degradation of ground water quality due to development of adverse salt balance in overdrawn basins is extremely difficult to ascertain, and long term records of mineral analyses of many wells are necessary to confirm adverse salt balance conditions. Unfortunately, insufficient long-term water quality records are available for the Lahontan Region, except for some basins at its southern boundary.

Brackish and Saline Springs and Lakes

Brackish and saline springs and lakes are a source of degradation to ground waters in the Lahontan Region. Widely scattered mineralized hot springs are associated with areas of extrusive volcanic rocks and are prevalent adjacent to major faults. The hot springs comprise a blend of highly mineralized hot water, which rises from great depths below the earth's crust, and circulating meteoric waters of relatively low total dissolved solids content. This mixture is generally a moderately hot water with high total dissolved solids content, that usually includes concentrations of boron, sodium, chloride, and sulfate far in excess of accepted domestic, irrigation, and industrial standards. These waters, if discharged to streams, impair the mineral quality of surface water in the area; they may also percolate directly into the sediments in the basin, causing direct impairment of the ground water.

Brackish and saline water bodies occur extensively beneath playa lakes formed in the lowest area of surface drainage basins in the Lahontan Region. The playas function as large evaporating pans gradually concentrating waters containing the mineral constituents brought in by flash floods, or rising waters, until the total dissolved mineral solids content equals or exceeds by many times the mineral content of sea water. In basins where extensive development of the ground water resources has occurred, a hydraulic gradient may be established which will allow saline waters underlying and in the vicinity of a playa to move into the zones of fresh water.

Water Quality Standards

Ground water in the Lahontan Region is used principally for domestic, municipal, and irrigation purposes with small amounts being used for industrial purposes. Suitability of the ground waters for each of these uses depends in large measure upon the amounts and the kinds of minerals dissolved therein. The water quality criteria used in this report are based on the United States Public Health Service Drinking Water Standards, 1962, and the classification of water for irrigational purposes by Dr. L. D. Doneen of the Division of Irrigation of the University of California at Davis.

To aid readers in interpreting the analyses given in Chapter V, and in evaluating the suitability of a particular water for a specific purpose, the Department of Water Resources has adopted for this report only, a set of water quality use ratings based upon the above-mentioned standards and classifications. The development of such use ratings from the United States Public Health Service Standards for domestic and municipal use, and the University of California irrigation criteria are discussed in this section.

Domestic and Municipal Use

Water that is used for drinking and culinary purposes should be clear, colorless, free from toxic salts; have no unpleasant taste or odor; should contain a minimal amount of dissolved mineral solids; and must be free of pathogenic organisms. The most widely used criteria in determining the suitability of a water for this use are the "United States Public Health Service Drinking Water Standards, 1962." These standards establish mandatory limits of maximum permissible concentration for certain mineral constituents and nonmandatory but recommended limits for others. Table 6 indicates these limits for drinking water.

The California State Board of Health has defined maximum safe amounts of fluoride ion in drinking water in relation to mean annual temperature.

Mean annual temperature in °F	Mean monthly maximum fluoride ion concentration in ppm
50	1.5
60	1.0
70 - above	0.7

Irrigation Use

Because of diverse climatological conditions, crops, and soils in California, it has not been possible to establish rigid limits for the quality of irrigation water to be used for all conditions involved. However, based on work done at the University of California, and at the Rubidoux and Regional Salinity Laboratories of the U.S. Department of Agriculture, water used for irrigation has been divided into three broad classes; Class 1, excellent to good; Class 2, good to injurious; and Class 3, injurious to unsatisfactory. Dr. L. D. Doneen has classified water to be used for irrigation purposes as shown in Table 7; this classification is used by the Department of Water Resources in determining water quality criteria for irrigation waters.

TABLE 6

UNITED STATES PUBLIC HEALTH SERVICE
DRINKING WATER STANDARDS
1962

Substance	Recommended concentrations in mg/l	Mandatory concentrations in mg/l
Alkyl Benzene Sulfonate (ABS)	0.5	--
Arsenic (As)	0.01	0.05
Barium (Ba)	--	1.0
Cadmium (Cd)	--	0.01
Carbon Chloroform Extract (CCE)	0.2	--
Chloride (Cl)	250.	--
Chromium (Hexavalent) (Cr^{+6})	--	0.05
Copper (Cu)	1.0	--
Cyanide (CN)	0.01	0.2
Fluoride (F)	(*)	(*)
Iron (Fe)	0.3	--
Lead (Pb)	--	0.05
Manganese (Mn)	0.05	--
Nitrate (NO_3)**	45.	--
Phenols	0.001	--
Selenium (Se)	--	0.01
Silver (Ag)	--	0.05
Sulfate (SO_4)	250.	--
Total Dissolved Solids (TDS)	500.	--
Zinc (Zn)	5	--

* Refer to Page 80.

** In areas in which the nitrate content of water is known to be in excess of the listed concentration, the public should be warned of the potential dangers of using the water for infant feeding.

Four criteria are generally used, as outlined by Dr. L. D. Doneen's classification, to determine the suitability of water for irrigation use: electrical conductivity (EC x 10^6 at 25° C), boron concentration, chloride concentration, and percent sodium.

TABLE 7

UNIVERSITY OF CALIFORNIA CRITERIA FOR IRRIGATION WATERS

Factor	Class 1 Excellent to good	Class 2 Good to injurious	Class 3 Injurious to unsatisfactory
Electrical Conductivity, EC$\times 10^6$ at 25° C	Less than 1,000	1,000 - 3,000	More than 3,000
Boron, ppm	Less than 0.5	0.5 - 2.0	More than 2.0
Chloride, ppm	Less than 175	175 - 350	More than 350
Percent Sodium	Less than 60	60 - 75	More than 75

Water Quality Use Ratings for the Lahontan Region

It is reiterated that the water quality use ratings given in Table 8 should be applied only for the purpose of this report. Due consideration was given to other factors such as climate, soil and crop types in arriving at the use ratings shown; in addition, physiological and aesthetic effects were considered for domestic use ratings. The availability of alternate sources has been, and continues to be, an important consideration in setting maximum limits on dissolved constituents in water in the Lahontan Region. Deviation from these criteria are permitted, therefore, except for the following highly toxic constituents: barium, lead, cyanide, cadmium, silver, arsenic, selenium, and hexavalent chromium.

On the basis of the water quality criteria and the standards discussed in this chapter, and with due consideration of the prevailing conditions, waters for domestic and irrigation use in the Lahontan Region are classified in one of three categories: suitable, marginal, or inferior. The constituents and the limits of concentration of these for each of the three categories are shown in Table 8.

TABLE 8

RATING OF WATER FOR DOMESTIC AND IRRIGATIONAL USES

Factor or constituent	Use rating		
	Suitable	Marginal[1]	Inferior
		Domestic[2]	
Total dissolved solids (TDS), ppm	0 - 1,000	1,000-2,000	Over 2,000
Nitrate (NO_3), ppm	0 - 45	45 - 88	Over 88
Fluoride (F), ppm	0 - 0.7	0.7 - 1.5	Over 1.5
Sulfate (SO_4), ppm	0 - 250	250 - 500	Over 500
		Irrigation	
Conductivity (EC $\times 10^6$ at 25° C)	0 - 1,500	1,500-3,000	Over 3,000
Boron (B), ppm	0 - 1	1 - 2	Over 2
Chloride (Cl), ppm	0 - 350	350 - 500	Over 500
Percent sodium	0 - 60	60 - 75	Over 75

1. The term marginal applies to waters that exceed the drinking water standards (Table 6) but could be used with appropriate restrictions. For example, waters containing nitrates in excess of 45 parts per million could conceivably be used by adults although there is a potential danger in using the water for the feeding of infants.
2. These use ratings are a general guide only. Interim standards for certain mineral constituents have been adopted by the California State Board of Health for domestic water supplies. Persons planning to use water that will be served to the public should contact the local health department.

Water quality problems, based on the water use ratings of various sources of supply in the Lahontan Region, are discussed in Chapter V. There are two additional factors which were considered in developing the irrigation and domestic ratings used. For irrigation use, water may have as much as one part per million of boron and still be considered suitable, because boron-sensitive crops constitute a minor proportion of the irrigated acreage in the Lahontan Region. In addition, the maximum allowable limits on conductivity and chloride concentration have been increased because of current irrigation practices and generally high permeability of the soils in the region. Good drainage conditions and generous applications of irrigation waters will usually prevent accumulation of harmful concentrations of dissolved salts in the root zone of irrigated crops.

Furthermore, in portions of the region where waters are used mutually for industrial and domestic purposes, the mandatory limits for the toxic constituents as set forth in the United States Public Health Service Drinking Water Standards should apply. The large number of specific quality requirements of water for industrial use prohibits inclusion of a classification for industrial waters in this report.

CHAPTER V. SUMMARY OF GROUND WATER BASINS AND WATER SUPPLY AND WATER QUALITY CHARACTERISTICS

Based on the geologic, hydrologic, and water quality data and findings resulting from this investigation, 55 ground water basins have been delineated within the boundaries of the Lahontan Region. This chapter presents a brief description of each of the ground water basins and summarizes the water supply and water quality characteristics of the basins.

Each basin is described in terms of location, areal extent, and general topography. Next, geologic features are discussed, particularly as they affect the occurrence and movement of ground water. This is followed by a discussion of the water supply, including its development and utilization in the basin, and water quality.

The description of each ground water basin is accompanied by a figure on which the basin boundaries have been delineated, and on which the locations of the various sampling points (wells, springs, streams) are given. Representative water quality data, including the water quality use rating, and depth to water or rate of flow at these sampling points are also tabulated.

Each of the basins has been named and numbered for ease in identification, and for planning future water resources investigations. Plate 1 indicates the name, number, and location of the ground water basins in the Lahontan Region.

The basin names (Mono Lake Valley Ground Water Basin) were derived from published and unpublished reports, United States Geological Survey and California Division of Mines maps, and local terminology.

Furnace Creek Ranch, Death Valley

Spence Air Photos

Although the hottest spot in the United States, Death Valley continues to be a prime tourist attraction.

The basin numbers (6-9) are part of the statewide hydrologic areal designation codes developed by the Department of Water Resources. The number to the left of the dash (6) indicates the Lahontan Region, one of the nine major geographic regions in the state. The number to the right of the dash (9) indicates a particular hydrologic unit within the region.

As discussed earlier, ground water basins are also grouped within a larger hydrologic unit called a drainage basin, and are numbered sequentially within the drainage basin, as shown on Plate 1. The sequence of drainage basins and ground water basins shown on that plate will be the order of their discussion in this chapter.

MONO LAKE DRAINAGE BASIN (NO. 11)

Mono Lake Valley Ground Water Basin (6-9)

Mono Lake Valley Ground Water Basin, shown on Figure 1, is a rectangularly shaped, northeasterly trending area of about 246 square miles located in the central portion of Mono County; it is the only ground water basin in the Mono Lake Drainage Basin (No. 11).

The ground water basin is bounded by the mountainous peaks of the Sierra Nevada on the west and by lower hills and ridges on the north, east, and south. The floor of the basin ranges in elevation from about 6,300 feet, to about 7,000 feet at the base of the surrounding mountains. To the east, Cowtrack Mountain rises to 8,875 feet; to the west, are two of the higher peaks of the Sierra Nevada: Parker Peak, at an elevation of 12,850 feet, and Mt. Dana, at 13,050 feet. Mono Dome, at an elevation of 10,612 feet, lies to the west of Leevining, the major settlement in this basin.

A major feature of the basin is Mono Lake which covers an area of 86 square miles and attains a maximum depth of 150 feet. The waters of this lake are unsuitable for prevailing beneficial uses because of their total dissolved solids content of about 60,000 ppm.

Geology

The basin is surrounded by Tertiary and Quaternary volcanic rocks except along the western edge where pre-Tertiary granitic and metamorphic rocks of the Sierra Nevada predominate. Quaternary Lake sediments and morainal deposits crop out in the basin and extensive dune sand deposits occur along the northern edge of Mono Lake. Recent alluvium forms the upper portion of the valley fill, which extends to a depth of at least 945 feet. The Recent alluvium which occurs in a relatively small area along the southwestern edge of Mono Lake generally consists of ryholitic pumice ejecta which is not typical of most of the valley fill.

Water Supply

The principal sources of water supply in the basin are deep penetration of direct rainfall and percolation of streamflow originating in the watershed. Surface waters recharge the ground water basin at a moderate rate through the moraines and alluvial fans fringing the basin.

The annual precipitation in the basin varies from about 10 inches on the valley floor to over 40 inches near the crest of the Sierra Nevada. Precipitation occurs predominantly as snow, over two-thirds of which occurs during the period from November through March. Surface runoff, derived principally from the melting of the resulting snowpack, occurs primarily in the spring and summer months.

Surface runoff within the Mono Lake Valley Ground Water Basin drains towards Mono Lake. The major streams, including Walker, Rush, Parker, Leevining, and Mill Creeks, flow into the basin from the east slope of the Sierra Nevada. The estimated amount of mean seasonal runoff in the basin, for the period 1894-95 through 1958-59, is 216,000 acre-feet.

Ground water occurs in unconsolidated alluvial deposits, in semiconsolidated older sediments, in glacial moraines, and in fractured volcanic material. Usable ground water supplies are derived from the Recent and underlying older alluvial deposits. The ground water movement is towards Mono Lake, and both free and confined ground water conditions exist.

The presence of artesian wells in the vicinity of Mono Lake indicates that portions of the water-bearing sediments near the edge of the lake are overlain by relatively fine-grained confining sediments. As a result, much of the ground water in the confined water-bearing sediments apparently discharges into Mono Lake below the surface. Evidence of this discharge is given by fresh water springs which occur within Mono Lake.

Water levels are at or near the ground surface in wells close to Mono Lake, but depths to ground water may be as much as 300 or 400 feet in the recharge areas along the higher alluvial slopes of the basin.

Development and Utilization. Development of the area started in the 1860's and 1870's with the working of mining claims near the towns of Aurora and Bodie situated in the mountains north of Mono Lake. Claiming populations of ten thousand each in the 1870's, these towns utilized springs and surface flows for water, with Bodie piping its water a distance of four miles from a spring on Potato Peak. Along with these developments, some ranching was attempted and lush meadows were heavily utilized for livestock grazing. Large amounts of lumber were also produced from the areas south and west of Mono Lake.

The population in the basin area was greatest in 1880 when there were several thousand people. As the mining boom subsided, however, the population eventually dropped to a low of about 200 in 1920; later, it rose again, reading about 600 by 1940 and has increased very slightly since that time.

In 1939 the City of Los Angeles completed a series of diversions and reservoirs on Leevining, Walker, Parker, and Rush Creeks, and constructed conveyance facilities to obtain an additional water supply. An average annual amount of 75,800 acre-feet of water has been exported from the basin to the city for the period 1947-48 to 1958-59. The reservoirs, streams, and lakes in the basin and the adjoining area are extensively utilized for fishing and recreational uses.

There is some irrigated pasture in the basin, but the amount of pasture actually being irrigated varies from year to year depending upon the amount of water available in any given year. Some 2,500 acre-feet of water is imported annually for irrigation from Virginia Creek via the Conway Summit Diversion. A land use survey by the Division of Water Resources in 1950 indicated that 2,000 acres were under irrigation. The Los Angeles City Department of Water and Power recorded about 3,700 acres of pasture were irrigated on city-owned land during the years 1953 through 1959.

The federal government and the City of Los Angeles own almost 83 percent of the land in the Mono Lake Drainage Basin. In 1931, the federal government withdrew from entry many acres of public land in the basin for protection of the city's water supply. This withdrawal, which forbids homesteading and farming, permits livestock grazing, mining, and recreation; it has restricted population growth and development of water supplies in the Mono Basin. Of these supplies, ground water comprises only a very small portion of the 6,800 acre-feet of water used annually for irrigation and domestic purposes in the basin.

Development of the Mono Lake Valley Ground Water Basin has also been restricted by lack of precipitation and concomitant water quality problems. The quantity of water flowing into Mono Lake each year is about 133,000 acre-feet but about 187,000 acre-feet evaporate from the lake during a year. As a result the level of Mono Lake has fallen 28 feet since 1919, and the average annual depletion of water in storage has been about 40,000 acre-feet from 1919 to 1959.

Water Quality. Runoff from the Sierra Nevada is of excellent quality and suitable for all beneficial uses. The total dissolved solids generally range from 60 to 400 ppm. As shown on Table 9, the ground water in the area northeast of Mono Lake is inferior for irrigation purposes, indicated by the high percent sodium in water sampled from Burkham Spring (3N/27E-10K1) and artesian well (3N/27E-35B1). Water from Warm Springs (2N/28E-17H2) has a total dissolved solids content of 2,060 ppm and is considered to be inferior for domestic and irrigation uses. The surface and ground waters in the western half of the basin are generally calcium bicarbonate in character but waters in the eastern half appear to be sodium bicarbonate.

Samples of water from Mono Lake have a total dissolved solids content of over 60,000 ppm, nearly twice the total dissolved solids concentration in the waters of the Pacific Ocean. The waters of Mono Lake are sodium chloride-carbonate in character, however, differing from those of the ocean which are generally sodium chloride.

Radioactivity levels of surface samples from Mono Lake range in beta-gamma activity from 383 ± 154 pc/l to 840 ± 720 pc/l during the period

October 3, 1953, to October 25, 1955. The radioactivity levels of the tributary streams and lakes are relatively low.

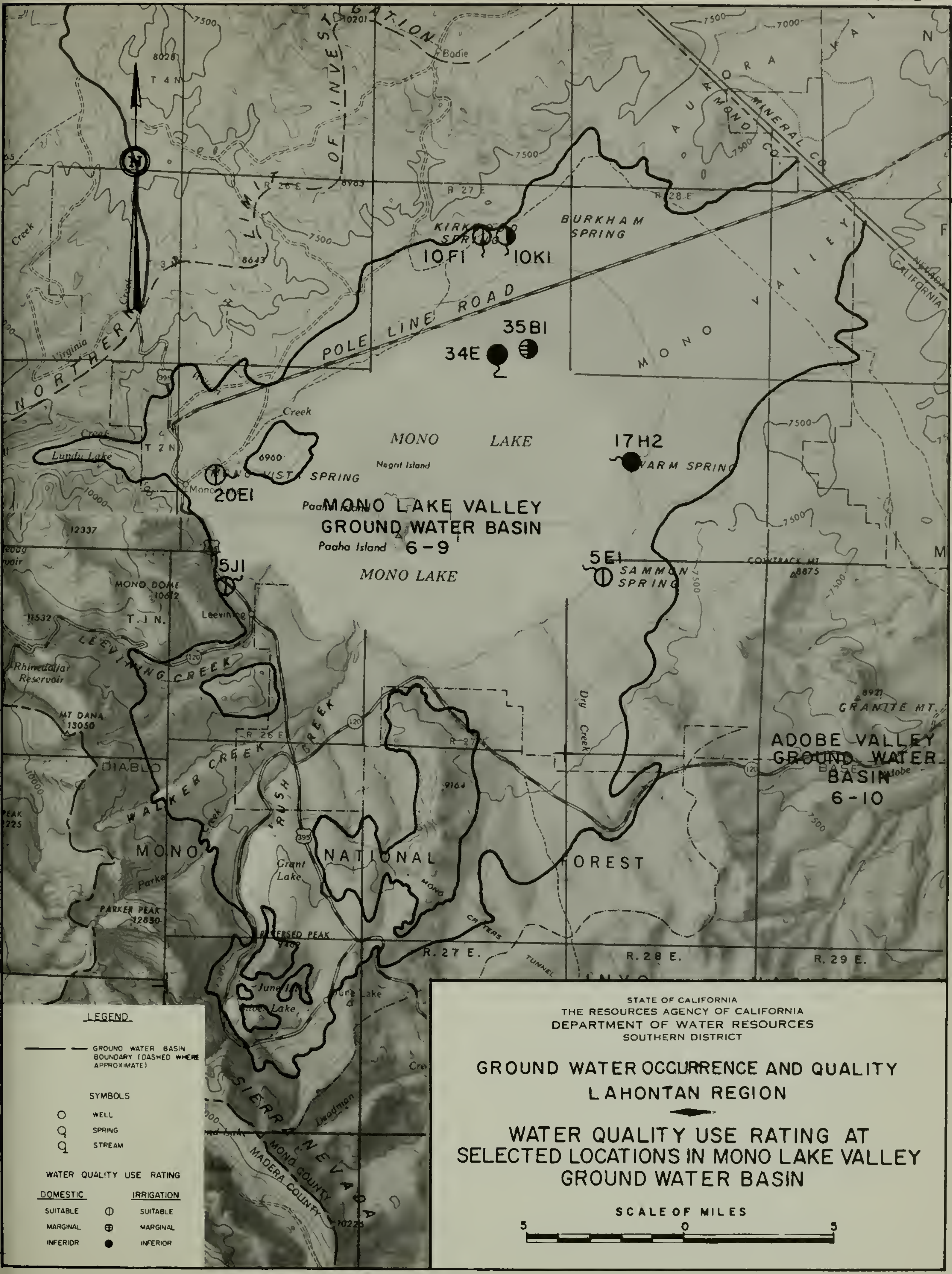
TABLE 9

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
MONO LAKE VALLEY GROUND WATER BASIN (6-9)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
1N/26E-5J1	DI						Ca HCO_3	6-23-60	flow	none
Sammon Spring 1N/28E-5E1	DI						Na HCO_3	7-6-60	flow	unknown
Mono Vista Spr. 2N/26E-20E1	DI						Ca HCO_3	7-6-60	flow	observation
Warm Spring 2N/28E-17H2			DI	F, % Na, EC	TDS, B		Na HCO_3	7-6-60	flow	unknown
Kirkwood Spring 3N/27E-10F1	DI						Na-Ca HCO_3	7-6-60	flow	unknown
Burkham Spring 3N/27E-10K1	D		I		% Na		Na HCO_3	7-6-60	flow	unknown
3N/27E-35B1		D	I	B, F	% Na		Na HCO_3-SO_4	7-6-60	flow	unknown
Mono Lake 3N/27E-34E			DI		% Na, B, F, SO_4, Cl, TDS, EC	383 ± 154 to 840 ± 720	Na Cl-CO_3	10-3-53 10-25-55	----	recreation

D - Domestic
I - Irrigation

FIGURE 1



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WATER QUALITY USE RATING AT SELECTED LOCATIONS IN MONO LAKE VALLEY GROUND WATER BASIN

ADOBE DRAINAGE BASIN (NO. 13)

Adobe Valley Ground Water Basin (6-10)

Adobe Valley Ground Water Basin, shown on Figure 2, is a northerly trending, irregularly-shaped area of about 62 square miles, located in the southern part of Mono County within the Adobe Drainage Basin (No. 13).

The bordering mountains which contain peaks ranging in elevation from 7,100 feet to 11,100 feet are the Benton Range on the east, the Glass, Granite, and Cowtrack Mountains on the west, and the Adobe Hills on the north. The basin surface varies in elevation from a low of 6,422 feet at Black Dry Lake to about 7,000 feet around the upper edges of the basin. There are three intermittent lakes in the basin: Adobe Lake in the north, River Spring Lakes in the east, and Black Lake in the southeast.

Geology

The Adobe Hills to the north and the highlands to the northeast and northwest consist of Tertiary volcanic rocks. The Benton Range to the east and southeast consists of pre-Tertiary granitic rocks while the highlands to the west consist of pre-Tertiary granitic rocks and Tertiary sediments and volcanic rocks.

The Quaternary alluvium, which is exposed over the basin floor, comprises the upper portion of the valley fill. Black Lake is a compound type playa.

Water Supply

The principal sources of water supply in the basin are deep penetration of direct rainfall and percolation of stream flow originating in the watershed. The estimated annual precipitation in the basin is about 11 inches. However, precipitation is somewhat higher on the surrounding mountains.

Most surface runoff in the basin occurs in the mountains along the western border with the runoff from several canyons merging to form Adobe Creek. This creek and Black Canyon are the principal channels conveying runoff in the basin which collects at Black Lake, the lowest point in the basin.

Alluvial fans extending northeastward from the Glass Mountains comprise the main recharge areas in the basin. Recharge through these fans probably occurs at low to moderate rates, and ground water movement appears to be easterly through the basin.

Usable ground water supplies are derived from the Recent and underlying older alluvial deposits and ground water may be available at shallow depths in a large portion of the basin. The occurrence of ground water at shallow depths is indicated by the fact that in four widely separated wells, shown on Figure 2, depth to ground water ranged from 9 to 32 feet.

Development and Utilization. Development of ground water supplies in the Adobe Valley Ground Water Basin has been limited because most of the land in the basin is in federal ownership and has been withdrawn from entry, except for stock grazing. The northeast and southwest sides of the basin constitute part of the Inyo National Forest and are unavailable for private uses. For this reason, ranching has been the principal development in the basin. Although most stock are grazed on nonirrigated land, a land use survey conducted in 1950 found that 2,300 acres of pasture were irrigated, using about 6,700 acre-feet of water. The survey also showed that water use for other purposes was negligible.

Water Quality. Ground water in Adobe basin is generally suitable for domestic and irrigation uses, as shown on Table 10. However, ground water obtained in the northern end is of marginal quality for irrigation because it has a high percent sodium. Ground water obtained from wells constructed near the dry lakes also has a high sodium content.

Water from well (1S/30E-12B1) has a calcium-magnesium bicarbonate character that may result from commingling of this well water with water from Black Canyon. However, ground water in most wells in this basin has a sodium bicarbonate character that indicates the influence of percolation from Adobe Creek.

The total dissolved solids content of ground water in Adobe basin ranges from 135 ppm to 284 ppm. In March 1962, a water sample collected from Adobe Creek contained 121 ppm of total dissolved solids, whereas a sample from Black Lake contained 920 ppm of total dissolved solids. However, the water sample from Adobe Creek is considered more representative of surface water in this basin.

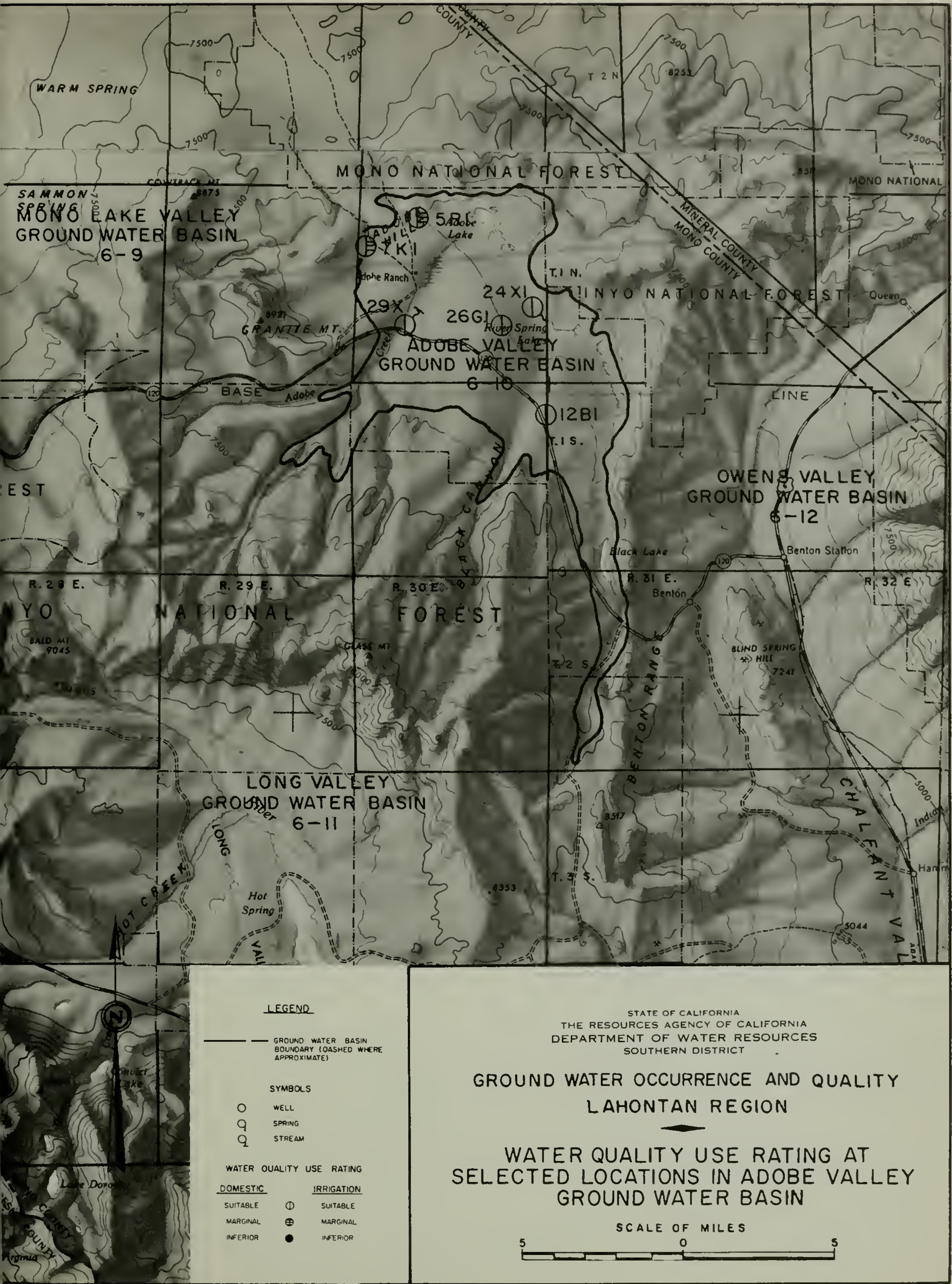
TABLE 10

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
ADOBE VALLEY GROUND WATER BASIN (6-10)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
1N/30E-5R1	D	I		% Na			Na HCO_3	8-14-59	9.1 ft.	stock
1N/30E-7K1	D	I		% Na			Na HCO_3	11-13-56	32.0ft.	stock
Spring 1N/30E-24X1	DI						Na HCO_3	3-15-62	2 cfs	unknown
1N/30E-26G1	DI						Na HCO_3	3-15-62	9.3 ft.	stock
Adobe Creek 1N/30E-29X	DI						Na-Ca HCO_3	3-15-62	5 cfs	unknown
1S/30E-12B1	DI						Ca-Mg HCO_3		----	stock

D - Domestic
I - Irrigation

FIGURE 2



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GROUND WATER OCCURRENCE AND QUALITY
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WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN ADOBE VALLEY
GROUND WATER BASIN

SCALE OF MILES

5 0 5

OWENS RIVER DRAINAGE BASIN (NO. 14)

Long Valley Ground Water Basin (6-11)

Long Valley Ground Water Basin, shown on Figure 3, occupies a predominately northerly trending arcuate-shaped area of about 119 square miles in the southern part of Mono County within the Owens River Drainage Basin (No. 14). The basin is bordered to the west and southwest by the Sierra Nevada, to the north by Bald Mountain and Glass Mountain, and by Round Mountain to the east. Mammoth Mountain to the west rises to 11,034 feet, while the mountains to the east rise to more than 10,000 feet in elevation. The surface of the basin floor ranges in elevation from about 6,780 feet at Lake Crowley, to about 7,800 feet in the Mammoth Lakes area.

Geology

Pre-Tertiary granitic rocks and Tertiary volcanic rocks occur to the north in the Bald and Glass Mountain areas. Tertiary and Quaternary volcanic rocks occur to the east, undifferentiated rocks to the south, and Quaternary volcanic rocks occur to the west in the Sierra Nevada.

Quaternary alluvium is exposed over part of the basin floor, comprising the upper portion of the valley fill, which extends to a depth of at least 80 feet. Pleistocene lake deposits occur along the margins of the basin except along the southern edge where Pleistocene glacial deposits are prominent in the Convict and Hilton Creek areas. Pressure areas occur in the northern part of the basin where the lake deposits act as a confining horizon to the underlying sediments.

Water Supply

The principal sources of water supply in the basin are deep penetration of direct rainfall and percolation of streamflow originating in the watershed. Precipitation ranges from about 10 inches per year on the floor of the basin to more than 40 inches per year in the Sierra Nevada. Melting snow, the major component of this precipitation, causes heavy runoff during spring and summer. Deadman, Mammoth, Convict, McGee, and Hilton Creeks convey most of the runoff from the Sierra Nevada to the Owens River or to Lake Crowley (Long Valley Reservoir). This runoff comprises the major portion of the mean seasonal natural runoff in the basin, which is estimated to be about 132,800 acre-feet.

Recharge to the basin occurs at a moderate to low rate in the Deadman and the Hot Creek areas. Ground water moves southeasterly toward the Owens River gorge area where it may seep through the tuffaceous deposits into Owens Valley. Usable ground water supplies are derived from the Recent and underlying older alluvial deposits. Local pressure conditions are indicated by flowing wells on the periphery of the basin.

Development and Utilization. In the Long Valley Basin, runoff from the Sierra Nevada provides the major source of water used for urban and irrigation purposes. Ground water provides a minor source.

In addition to the water derived from the lower portion of the basin and runoff obtained from precipitation on the higher margins of the basin, water has been imported from Mono Lake Valley Ground Water Basin at the average rate of 75,800 acre-feet per year (1947-48 to

1958-59). However, this imported water is not a source of supply but is used to regulate the flow in the Owens River. The imported water enters the basin through the Mono Craters tunnel, flows to the Owens River to the Long Valley Reservoir where it is stored, and then is released to regulate the flow in the Owens River and the Los Angeles Aqueduct.

A considerable amount of water is lost from the basin through evapotranspiration. Based on an evaporation rate of 2.4 feet per year, the annual loss from Lake Crowley is estimated to be 10,000 acre-feet. The area where a high ground water table exists is estimated to be 8,000 acres. Assuming that unit water use is two feet per year when the average depth to ground water is three feet, the evapotranspiration could be as much as 16,000 acre-feet per year.

The major area of the basin, a part of the Inyo National Forest, is used for recreational purposes, including hunting, boating, camping, and fishing. The land submerged by and bordering Lake Crowley and the Owens River is owned by the City of Los Angeles and is used in operation of their water supply facilities. Only a small part of the basin comprises privately-owned lands, consisting of ranches and other agricultural lands.

Irrigated acreage in the basin is less than that of the early 1900's, but land use surveys show that it may be increasing. A land use survey made in 1950 indicated that about 2,900 acres were being irrigated, of which most was hay or pasture land; the annual water use for irrigation and urban uses was 7,000 acre-feet. Records of the Los Angeles Department of Water and Power for the late 1950's indicate that about 4,600 acres of city land were irrigated pasture.

The Long Valley Ground Water Basin has a permanent population of approximately 500; about 400 of whom live in the Mammoth Lakes area. During summer, the basin usually is visited by vacationers and sportsmen in the thousands who use the recreation facilities at Mammoth Lakes and at Lake Crowley.

Water Quality. Mineral analyses of water samples indicate that most sources of ground water except for those in the Hot Creek area, contain water of suitable quality as shown on Table 11. In the Hot Creek area most sources contain water of marginal or inferior quality. Except for Hot Creek and Mammoth Creek sources of surface water are also of suitable quality. The character of the ground and surface water supplies is either calcium or sodium bicarbonate.

In the Hot Creek area water of inferior or marginal quality is obtained from hot springs and steam wells. Water from most of these sources contains about 900 ppm to about 1,500 ppm of total dissolved solids, and as much as 4 ppm of fluoride and 10.4 ppm of boron. Discharge from the hot springs is increasing the concentration of boron and fluoride and the percent sodium in Hot Creek, and is adding boron to Lake Crowley, which stores water for the Los Angeles Aqueduct.

Waste that is discharged from wells drilled in the Hot Creek area to obtain steam for generation of electrical energy impairs the quality of water in Mammoth Creek. The waste discharged from the wells contains excessive amounts of fluoride, boron, and arsenic. Analyses of water samples taken a short distance downstream from the area of waste discharge show that the concentrations of these constituents exceed the limits for domestic use. However, at a greater distance downstream (near Highway 395) the concentrations of these constituents are less than the limits.

In the northwestern part of the basin, two wells produce water with high fluoride concentration. Because of this fluoride level, the water has been classified as inferior for domestic uses.

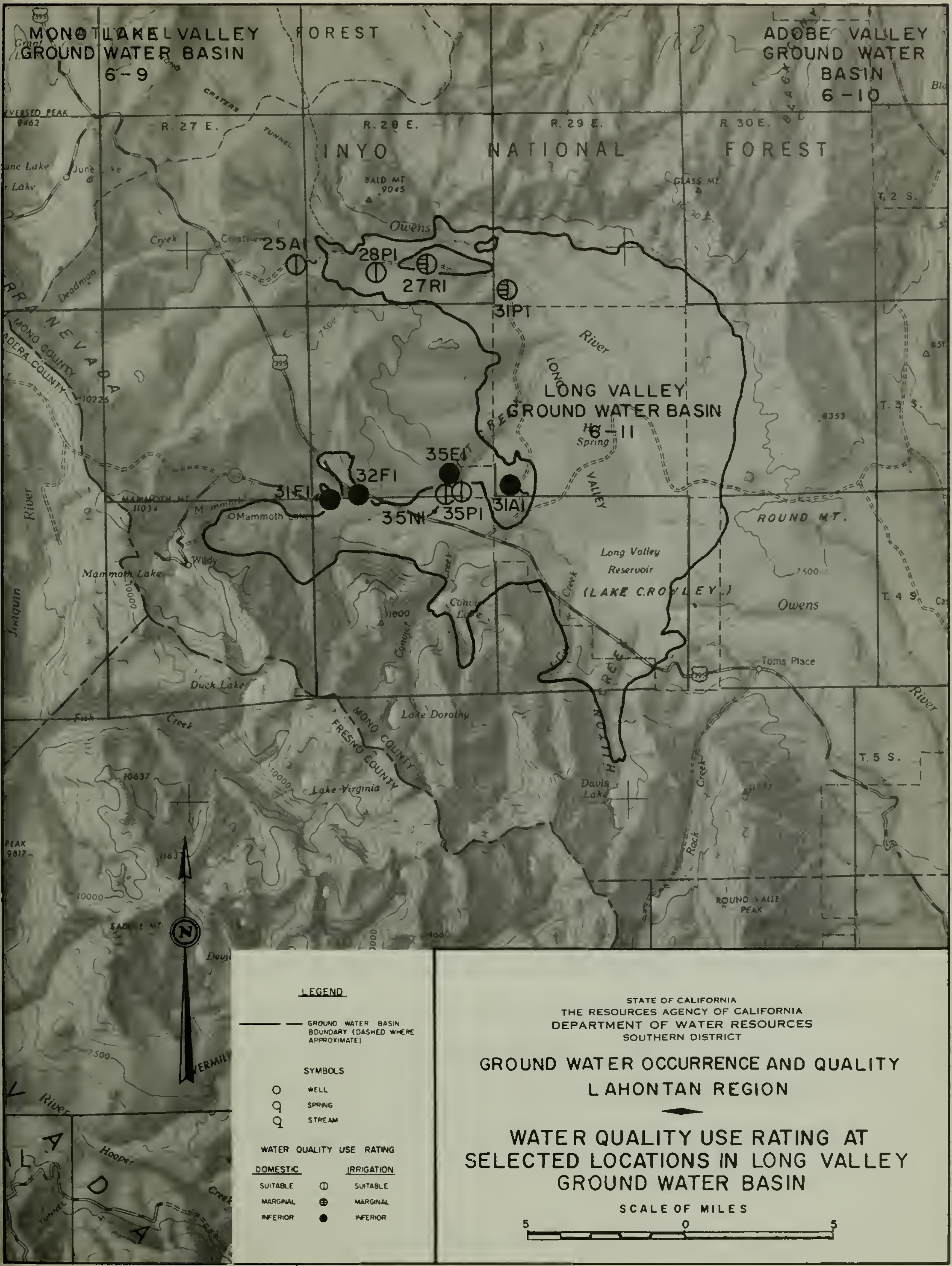
TABLE 11

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
LONG VALLEY GROUND WATER BASIN (6-11)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification			Basis for Classification		Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
2S/27E-25A1	DI						Na HCO_3	6-25-60	flow	unknown
2S/28E-27R1	I	D		F			Ca Cl	6-25-60	36.0 ft	unknown
2S/28E-28P1	DI						Ca HCO_3			unknown
2S/29E-31P1	I	D		F			Na HCO_3			stock
3S/28E-31F1			DI	EC, TDS	F, B, % Na		Na Cl-HCO_3	10-20-60	flow	steam power
3S/28E-32F1			DI	EC, TDS	F, B, % Na		Na Cl-HCO_3	10-20-60	flow	steam power
3S/28E-35E1			DI	EC, TDS	F, B, % Na		Na Cl-HCO_3	12-29-60	flow	steam power
3S/28E-35N1	DI						Na-Mg HCO_3			fish hatchery
3S/28E-35P1	DI						Na-Mg HCO_3			fish hatchery
3S/29E-31A1			DI		F, B, % Na		Na HCO_3	6-25-60	flow	unknown

D - Domestic
I - Irrigation

FIGURE 3



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GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN LONG VALLEY GROUND WATER BASIN

Owens Valley Ground Water Basin (6-12)

Owens Valley Ground Water Basin, shown on Figure 4, is a long, narrow, northerly trending area of 1,031 square miles located in the western part of Inyo County and in the southeastern corner of Mono County, within the Owens River Drainage Basin (No. 14). The main towns in the area of the basin are Lone Pine, Independence, Big Pine, and Bishop.

The basin lies south of Long Valley in a structural trough between the White and the Inyo Mountains on the east, and the Sierra Nevada on the west. Elevation of the basin floor ranges from about 3,550 feet at Owens Dry Lake to about 6,000 feet in the northern end of the basin. The Sierra Nevada contains many high peaks and rises to a maximum elevation of 14,495 at Mt. Whitney; the mountains to the east also contain precipitous peaks which rise to more than 11,000 feet.

Geology

The major geologic units in the White and Inyo Mountains to the east are Precambrian and Paleozoic sediments and metasediments and pre-Tertiary granitic rocks; Triassic metasediments and metavolcanic rocks also occur in the Inyo Mountains. The Coso Range to the south and southeast consists of Tertiary-Quaternary sediments, Quaternary volcanic rocks, and Tertiary and/or Quaternary volcanic rocks, and Tertiary and/or Quaternary sediments. The major geologic units in the Sierra Nevada to the west are the pre-Tertiary granitic rocks, but Quaternary volcanic rocks and numerous other rock types also occur in the Sierra Nevada.

Pleistocene glacial deposits occur in several glaciated valleys of the Sierra Nevada such as in the canyon of Big Pine Creek which contains a large moraine. Quaternary dune sand deposits occur along the eastern periphery of Owens Dry Lake, a playa created by man's activities. Quaternary alluvium is exposed over much of the basin floor, comprising the upper portion of the valley fill which extends to a depth of at least 1,200 feet. Pressure areas exist in portions of the basin, and faults which have a predominately northwesterly trend may act as barriers to ground water movement.

Water Supply

The principal sources of water supply in the basin are deep penetration of direct rainfall and percolation of stream flow originating in the watershed. The average annual precipitation on the valley floor ranges from a minimum of about three inches in the south to about nine inches in the north. Near the crest of the Sierra Nevada, the annual precipitation is more than 40 inches and occurs mainly as snow.

Surface runoff consists mainly of the melting snowpack from the Sierra Nevada and is greatest during the spring and summer. The estimated mean seasonal natural runoff for the valley is 377,200 acre-feet. Most of this runoff flows to the Owens River and then southerly towards Owens Lake.

A large portion of the runoff, however, does not reach Owens Lake or recharge the ground water basin because it is diverted from the Owens River by the Los Angeles Department of Water and Power for exportation to Los Angeles. In addition to export of runoff from the basin, an average of 201,980 acre-feet of water is released annually from Lake Crowley in Long Valley to the Owens River for diversion to the Los Angeles Aqueduct. The water in the Owens River is diverted to the aqueduct a few miles south of Tinemaha Reservoir. An average of 329,464 acre-feet is exported annually to Los Angeles.

The ground water basin is recharged at a moderate-to-high rate through the alluvial fans and the moraines of the Sierra Nevada and the Inyo Mountains, and also may be recharged by ground water inflow from Long Valley. There appears to be no outflow from the Owens Valley ground water basin.

Usable ground water supplies are derived from the Recent and underlying alluvial deposits. The existence of pressure conditions is demonstrated by numerous flowing wells and springs in the vicinity of the Owens River in both the Bishop and the Independence areas.

The depth to ground water ranges from flowing conditions in the lower parts of the basin to a few hundred feet in the alluvial slopes, and in extensive portions of the basin ground water levels are near or at the surface.

Water levels generally have not been depressed in the Owens Valley Ground Water Basin. Despite historical water level records that show pumping by the City of Los Angeles during the late 1920's and early 1930's did lower the water levels in the Bishop and Independence areas, more recent records indicate that these levels have again risen above these depressed levels.

<u>Development and Utilization</u>. Diversions of water from the Owens River and from numerous creeks comprise the main water supply in Owens Valley. Small quantities of ground water are used in the areas of the ground water basin where surface runoff is unavailable and when surface

supplies are insufficient to provide the export requirements of the City of Los Angeles.

Development of the ground water basin began about 1860 when prospectors began staking mining claims. Subsequent development of mining claims was an impetus for establishment of many towns and numerous ranches. Because surface water supplies provided abundant quantities of water, ground water supplies were used in only minor quantities for irrigation of hay and pasture lands. Several diversion canals were constructed to convey surface water supplies to large areas of the basin, and farming became so successful that 50,000 acres of crops were irrigated prior to construction of the Los Angeles Aqueduct in 1912. However, the large export of water to Los Angeles has virtually eliminated irrigated agriculture in the economy of this basin and that of the Mono Basin.

Population in the basin has slowly but steadily increased except during the early mining years. No complete records are available prior to 1870, but the mining town of Cerro Gordo claimed that it had a population of 2,000 in the 1860's. By 1958, the population of the basin had increased to approximately 11,000, about half of whom reside in Bishop.

The City of Los Angeles utilizes the ground water basin as an underground reservoir in addition to its use as a major source of surface water export. During years when the water supply in the basin exceeds export requirements, the city applies excess water to recharge the ground water basin. The recharge provides a supplemental supply to be withdrawn during periods of low runoff or drought.

Water-spreading operations are conducted downstream from the Pleasant Valley Reservoir principally in the Bishop area on both sides of the Owens River. These operations help maintain high flows in the Owens River, supplementing the supply to Tinemaha Reservoir. Water spreading operations are also conducted downstream from Tinemaha Reservoir in the Independence area.

The City of Los Angeles owns several hundred wells in the valley. Artesian flows are diverted continually to the Los Angeles Aqueduct, but water from other wells is utilized only during dry periods when surface and artesian water supplies are insufficient to meet the demands of the City of Los Angeles. In addition, nearly all the flow in the Owens River is diverted to the Los Angeles Aqueduct. This flow included an average of 201,981 acre-feet of water per year (1947-48 to 1957-58) released from the Long Valley Reservoir.

A pipeline diverts the flow from the Owens River Gorge to power plants for the production of electricity. The flow is then returned to the Owens River and travels downstream through Pleasant Valley Reservoir (storage capacity of 3,800 acre-feet) and Tinemaha Reservoir (storage capacity of 16,405 acre-feet). Downstream from Tinemaha Reservoir a canal diverts the water to Haiwee Reservoir (storage capacity of 58,000 acre-feet) from which an average of 329,464 acre-feet of water per year (1947-58 to 1958-59) was released for export to Los Angeles.

The City of Los Angeles leases some acreages for agricultural development. During years when the water supply in the basin exceeds the exportation requirements, the city makes water available for irrigation of these leased lands. These leased lands averaged about 22,000 acres for the period 1953 through 1959. There were also an estimated 40,000 acres of grazing land subject to intermittent irrigation during 1956-1958. In addition to the lessees of the property of The City of Los Angeles, a number of individuals operate privately owned ranches. Parts of these ranches are irrigated primarily by diversions of water from streams. A land use survey conducted in 1950 by the Division of Water Resources indicated that about 7,000 acres were irrigated in the Owens Valley, including both privately owned lands and lands leased from the City of Los Angeles. It is estimated the annual urban and irrigation was use is about 25,000 acre-feet.

A large portion of the water supply to the basin is consumed by evaporation and phreatophytes. Evaporation from the lakes and streams has not been calculated, but the loss from reservoirs, as shown in the following tabulation is about 10,800 acre-feet per year. Phreatophytes release large quantities of ground water through evaporation and transpiration. The quantity of evapotranspiration in this basin, as shown in the following tabulation, is estimated to be about 275,000 acre-feet per year.

EVAPORATION AND EVAPOTRANSPIRATION IN OWENS VALLEY

Reservoir or area	Average annual net rate of evaporation or evapotranspiration (in feet)	Average annual evaporation or evapotranspiration (in acre-feet)
Pleasant Valley Reservoir	4.5	500
Tinemaha Reservoir	5.5	5,700
Haiwee Reservoir	3.9	4,600
Subtotal (evaporation)		10,800
Possible evapotranspiration from areas of high ground water table in Bishop and Independence areas	2.5 for an average depth to ground water of 3 feet	250,000
Owens Dry Lake	Estimate	25,000
Subtotal (evapotranspiration)		275,000
GRAND TOTAL		285,800

In summary, water use comprises more than 329,000 acre-feet of water lost from the basin users annually through export, about 285,000 acre-feet through evapotranspiration, and about 25,000 acre-feet of water used in the basin for domestic and agricultural purposes.

Water Quality. Throughout most of the Owens Valley Ground Water Basin, ground water is of suitable quality, as shown on Table 12, and has a total dissolved solids content ranging from 100 to 400 ppm. In some localities, however, ground water is of marginal or inferior quality for domestic and irrigation uses due to its fluoride and boron concentrations or high percent sodium content.

In areas in the northern end of the basin, near Benton Station and near Bishop, some of the ground water supplies have fluoride concentrations and percent sodium in the marginal and inferior ranges. In these areas fluoride concentrations range from 0.2 to 9.0 ppm with a median of 1.2 ppm, and the percent sodium ranges from 18 to 92 percent with a median of 58 percent. The highest concentrations of fluoride and the highest percent sodium in the area occur in springs on the west side of the basin, south of Bishop. Keough Hot Springs is one source of water containing a high fluoride concentration.

Ground water of suitable quantity is found in Round Valley and Independence areas. However, water from a few wells which are located about seven miles north of Independence is of inferior quality for irrigated agriculture due to boron concentrations which are as high as 7.6 ppm.

The ground water in the area around Owens Lake in the south is generally inferior in quality. A number of wells have been drilled in and around Keeler, on the east side of the lake, in attempts to find water suitable for irrigation or domestic use. However, the water obtained from these wells was considered marginal for domestic uses and inferior for irrigation uses. South of the lake, ground water of suitable quality is obtained at Cartoga, at Olancha, and in the area south of Olancha.

Ground water under the Owens Lake bed is highly mineralized and is utilized for production of sodium carbonate and borax. A water sample obtained from well 17S/37E-33E1 in the central portion of the lake had a total dissolved solids content of 453,000 ppm, a content about 14 times that of water from the Pacific Ocean.

The character of nearly all the ground water in the valley ranges from calcium bicarbonate to sodium bicarbonate or combinations thereof. However, water from a few wells in the Round Valley area contains sulfate as one of the predominating anions, and ground water from Keough Hot Springs and Owens Lake bed is sodium chloride in character.

Ground water, as previously mentioned, is used to supplement the surface water supply to the Los Angeles Aqueduct. As pointed out, some of the ground waters supplies are of poor quality. When these poor quality waters are mixed with surface water, however, the final mixture is generally of suitable quality. The water in the Owens River has such a low salt content that even the heavily mineralized ground waters are diluted sufficiently when mixed with adequate quantities of the river water.

The character of the surface waters in the basin, like that of the ground water, varies from calcium bicarbonate to sodium bicarbonate and combinations thereof.

There appears to be no pollution problem with sewage effluent in the valley. The sewage treatment plants, located at the main population centers, discharge effluents to waste lands except at Bishop where the effluent is used to irrigate pasture land.

TABLE 12

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
OWENS VALLEY GROUND WATER BASIN (6-12)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification			Water Quality Use Rating: Basis for Classification		Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
Benton Station 1S/32E-29D1	I	D		F		16.8 ± 1.8	Ca HCO_3	11-13-56	125.9ft	Domestic
-31J2	DI						Ca HCO_3	11-13-56	44.5ft	None
-32E1	I		D		F		Ca HCO_3	11-13-56	62.4ft	Domestic
2S/31E-2X1			DI		F, % Na		Na CO_3-SO_4	3-15-62	Flow	Domestic Irrigation
Milner Creek 4S/33E-16	DI						Ca HCO_3	4-17-56	Flow	Unknown
5S/33E-9K1	DI						Ca HCO_3	6-23-60	32 ft	Domestic
Fish Slough 5S/33E-18D1	DI						Ca HCO_3	6-23-60	Flow	Unknown
Round Valley 6S/31E-5H1	DI						Ca HCO_3	-----	-----	Domestic
-17B1	DI						Ca-NaSO_4-HCO_3	6-25-60	18 ft	Domestic
-20H1	DI					7.1 ± 2.1	Ca HCO_3-SO_4	-----	-----	Domestic

D - Domestic
I - Irrigation

TABLE 12

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
OWENS VALLEY GROUND WATER BASIN (6-12)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Round Valley 6S/31E-22B1	DI						Ca HCO_3	2-8-61	16.1 ft	Domestic
6S/32E-25Q1	DI						Ca HCO_3			Domestic
Bishop 6S/32E-32M1	DI					7.6 ± 1.2	Ca HCO_3			Domestic
6S/33E-27E1	DI						Ca-Na HCO_3			Domestic
-33R1	I	D		F			Na HCO_3	7-14-55	flow	None
7S/32E-2Q1	DI						Ca HCO_3	7-14-55	flow	None
-12E1		DI		% Na, F			Na HCO_3	7-14-55	flow	Municipal
-26A1*			DI		% Na, F		Na SO_4-HCO_3	4-7-54	flow	Domestic Mining
7S/33E-3L1		DI		% Na, F			Na HCO_3	7-14-55	flow	None
-4M1	DI						Ca-Na HCO_3			Domestic

D - Domestic
I - Irrigation

TABLE 12

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
OWENS VALLEY GROUND WATER BASIN (6-12)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
7S/33E-6P1		I	D	% Na	F		Na HCO_3	7-14-55	flow	Municipal
-10H1	I	D		F			Na HCO_3	7-14-55	flow	None
-14D1	I	D		F			Na HCO_3	7-14-55	flow	None
-23G1		I	D	% Na	F		Na HCO_3	7-14-55	flow	None
-25K1		DI		% Na, F			Na HCO_3	7-14-55	flow	None
-26C1	I	D		F			Na HCO_3	7-14-55	flow	None
-36D1	I	D		F			Na HCO_3	7-14-55	flow	None
Big Pine - Bishop 8S/33E-2B1		I	D	% Na	F		Na HCO_3	7-14-61	flow	None
-5G1	DI						Ca HCO_3	7-14-61	127 ft	Domestic
-6R1*	I		D		F		Na HCO_3-SO_4	4-7-54	flow	Domestic Irrigation

D - Domestic
I - Irrigation

TABLE 12

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
OWENS VALLEY GROUND WATER BASIN (6-12)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Keough Hot Spring 8S/33E-17G1*			DI		% Na, F		Na Cl	1-26-55	flow	Bathing
-24M1	I	D		F			Na HCO_3	7-14-55	flow	Municipal
Big Pine-Bishop 8S/34E-24B1	DI						Ca HCO_3	6-17-61	flow	Unknown
9S/34E-33D1	DI						Ca-Na HCO_3			Municipal
10S/34E-26F1	DI						Na-Ca HCO_3			Domestic
Big Seeley Spring 11S/34E-2K1*	D	I		B			Na-Ca HCO_3	7-14-55	flow	Domestic
Independence 12S/34E-2N1	DI						Ca-Na HCO_3			Domestic
-22K1	DI						Ca-Na HCO_3	7-14-55	flow	None
-26E1	D		I	EC	B, % Na		Na HCO_3	7-14-55	flow	None
-26P1	DI						Ca-Na HCO_3	7-14-55	flow	None

D - Domestic
I - Irrigation

TABLE 12

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
OWENS VALLEY GROUND WATER BASIN (6-12)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
13S/35E-5K1	DI						Ca HCO_3	7-14-55	flow	None
-15N1	DI						Na-Ca HCO_3	7-14-55	flow	None
3S/35E-34E1	DI					4.8 ± 1.3	Ca HCO_3	7-14-55	flow	Municipal
14S/35E-11M1	DI						Ca-Na HCO_3			Municipal
14S/36E-19N1	DI						Ca-Na HCO_3	7-14-55	flow	Domestic Stock
-31A1	DI						Na HCO_3			Observation
Lone Pine 15S/36E-28F1	DI						Ca HCO_3			Domestic
-32E1*	DI						Na-Ca HCO_3			Domestic
-33J1	I	D		F			Ca HCO_3			Domestic
-34D1	I	D		F			Ca-Na HCO_3			Domestic

D - Domestic
I - Irrigation

TABLE 12

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN OWENS VALLEY GROUND WATER BASIN (6-12)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
16S/36E-15F1	DI						Ca-Na HCO_3			Domestic
Bartlett 17S/36E-1K1		D	I	F	% Na		Na HCO_3			Municipal
-12C1			DI	EC, TDS	B, F, % Na		Na Cl-HCO_3	7-15-55	flow	Unknown
Owens Lakebed 17S/37E-33E1			DI		EC, TDS, B, % Na, SO_4 NO_3, Cl		Na Cl			Industrial
Keeler 17S/38E-5H2		D	I	TDS, EC	% Na, B		Na HCO_3	7-15-55	flow	Domestic
-18Q1			DI		TDS, EC, F, B, % Na		Na HCO_3			None
-22B1*			DI		TDS, EC, F, B, % Na, Cl SO_4		Na HCO_3	7-15-55	flow	None
Cartago 18S/37E-6Q1			DI	TDS, EC	F, B, % Na		Na HCO_3			Industrial
-31K1	DI						Ca-Na HCO_3			Municipal
Dirty Socks Hot Springs -34A1			DI	F	TDS, EC, B, % Na, Cl		Na HCO_3-Cl	11-17-54	flow	None

D - Domestic
I - Irrigation

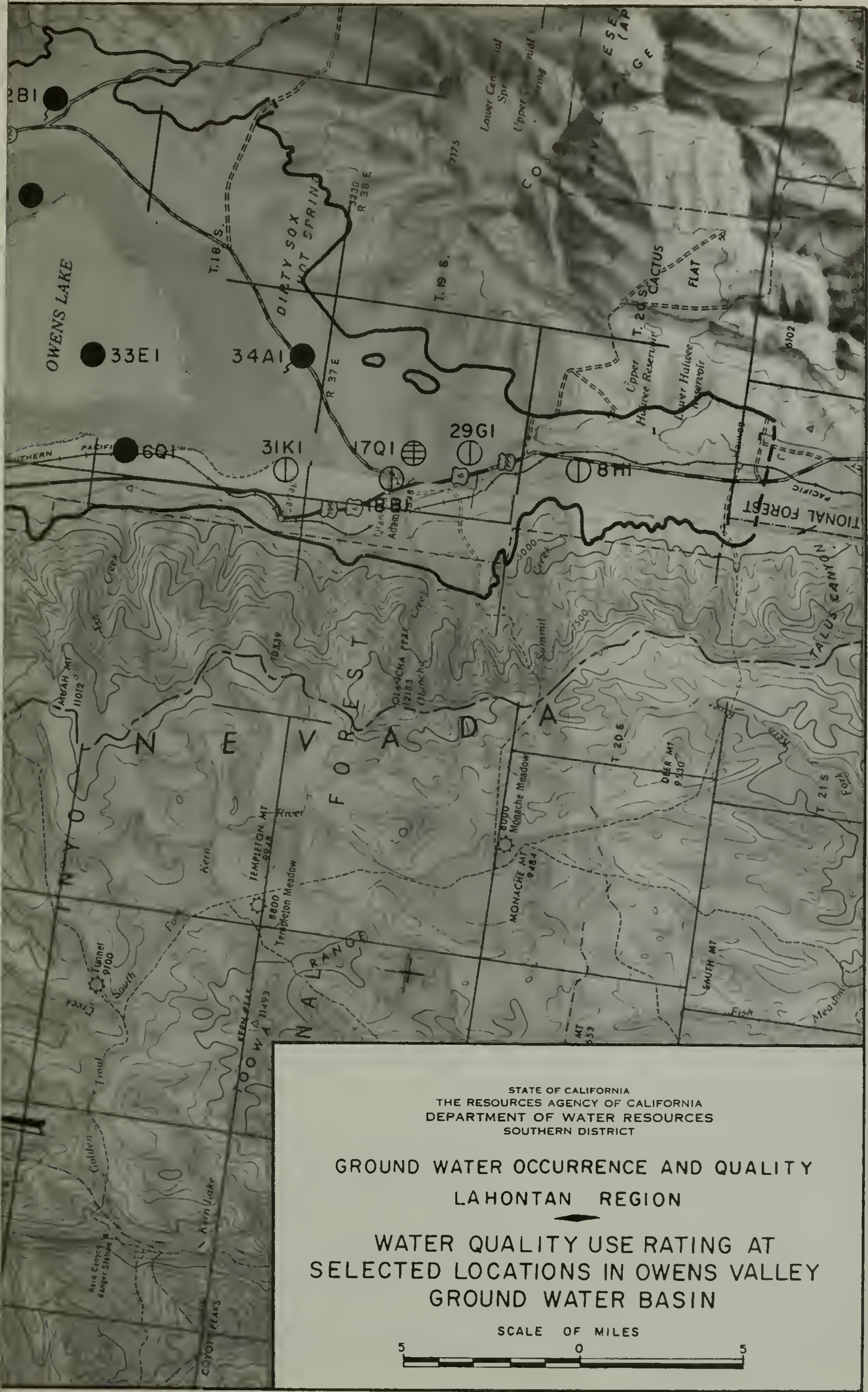
TABLE 12

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
OWENS VALLEY GROUND WATER BASIN (6-12)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Olancha 19S/37E-17Q1		DI		F, B			Na HCO_3-Cl	7-15-55	9 ft	Unknown
-18B1	DI					13.7 ± 1.7	Ca HCO_3			Domestic
-29G1	DI						Na HCO_3			Irrigation
20S/37E-8H1	DI						Ca-Na HCO_3	3-19-54	12 ft	Domestic

D - Domestic
I - Irrigation
*Spring

FIGURE 4



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GROUND WATER OCCURRENCE AND QUALITY
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WATER QUALITY USE RATING AT SELECTED LOCATIONS IN OWENS VALLEY GROUND WATER BASIN

SCALE OF MILES
5 0 5

LEGEND

GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)

SYMBOLS

○ WELL

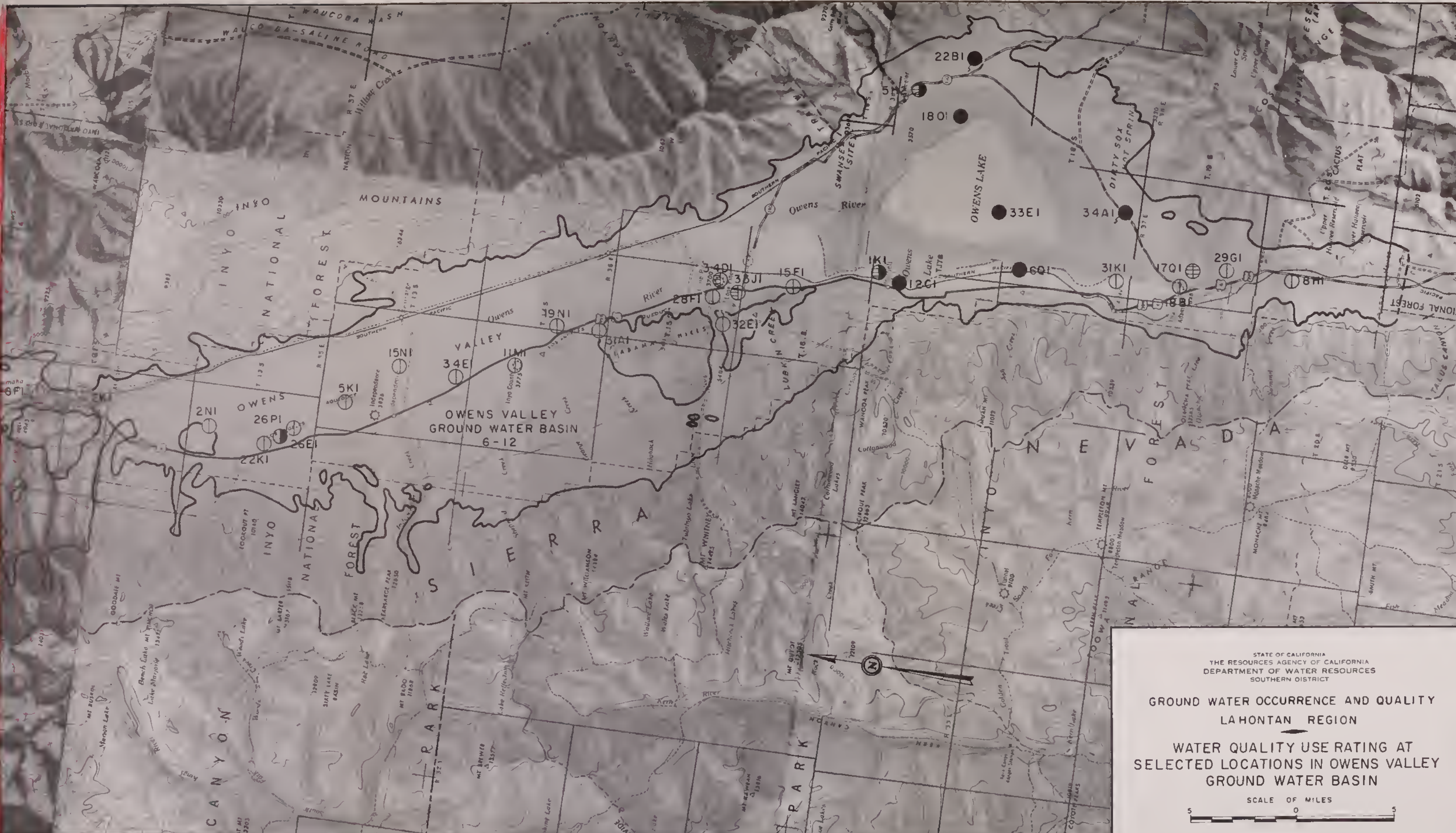
SPRING

STREAM

WATER QUALITY USE RATING

DOMESTIC		IRRIGATION
SUITABLE	⦶	SUITABLE
MARGINAL	⊕	MARGINAL
INFERIOR	●	INFERIOR

FIGURE 4



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WATER QUALITY USE RATING AT SELECTED LOCATIONS IN OWENS VALLEY GROUND WATER BASIN

Centennial Valley Ground Water Basin (6-13)

Centennial Valley Ground Water Basin, shown on Figure 5, is a northwesterly trending, roughly triangular-shaped area of about 46 square miles in the central western part of Inyo County at the southeastern end of the Owens River Drainage Basin (No. 14).

The basin is bounded by the Inyo Mountains on the north and northeast and the Coso Range on the south and west. The basin floor ranges in elevation from 4,300 feet in the northwest to 5,500 feet in the southeast. Maximum elevations of the surrounding mountains are more than 7,000 feet.

Geology

Paleozoic sediments and Tertiary-Quaternary volcanic rocks occur in the Inyo Mountains to the north and northeast. Pre-Tertiary granitic rocks occur in the hills to the east and in the Coso Range to the south and west. Quaternary volcanic rocks also crop out in the Coso Range.

Tertiary and/or Quaternary sediments occur in the western and northwestern portions of the basin. Quaternary alluvium, which is exposed over most of the basin floor, comprises the upper portion of the valley fill.

Water Supply

The principal source of ground water replenishment in the Centennial Valley Ground Water Basin is percolation of streamflow originating in the watershed. The basin receives three to four inches of precipation annually. Surface runoff from many small washes and gullies drains to an axial wash in the northwest end of the basin, flowing out of the basin to Owens Dry Lake. Surface waters recharge the ground water basin at a moderate rate through the alluvial fans fringing the basin.

Most of the basin is susceptible to recharge and it appears probable that usable ground water supplies could be derived from the Recent and underlying older alluvial deposits. The direction of ground water movement in the basin is northwesterly, towards Owens Valley.

Development and Utilization. Mining in the surrounding mountains appears to be the only development in the area, but even mining activities have almost ceased. The major mining operation in the Talc City Mine, the largest single source of steatite-grade in the United States. The water supply for this mining activity was hauled in from nearby towns or obtained from springs in the Coso Range. Very little water is presently used in the basin.

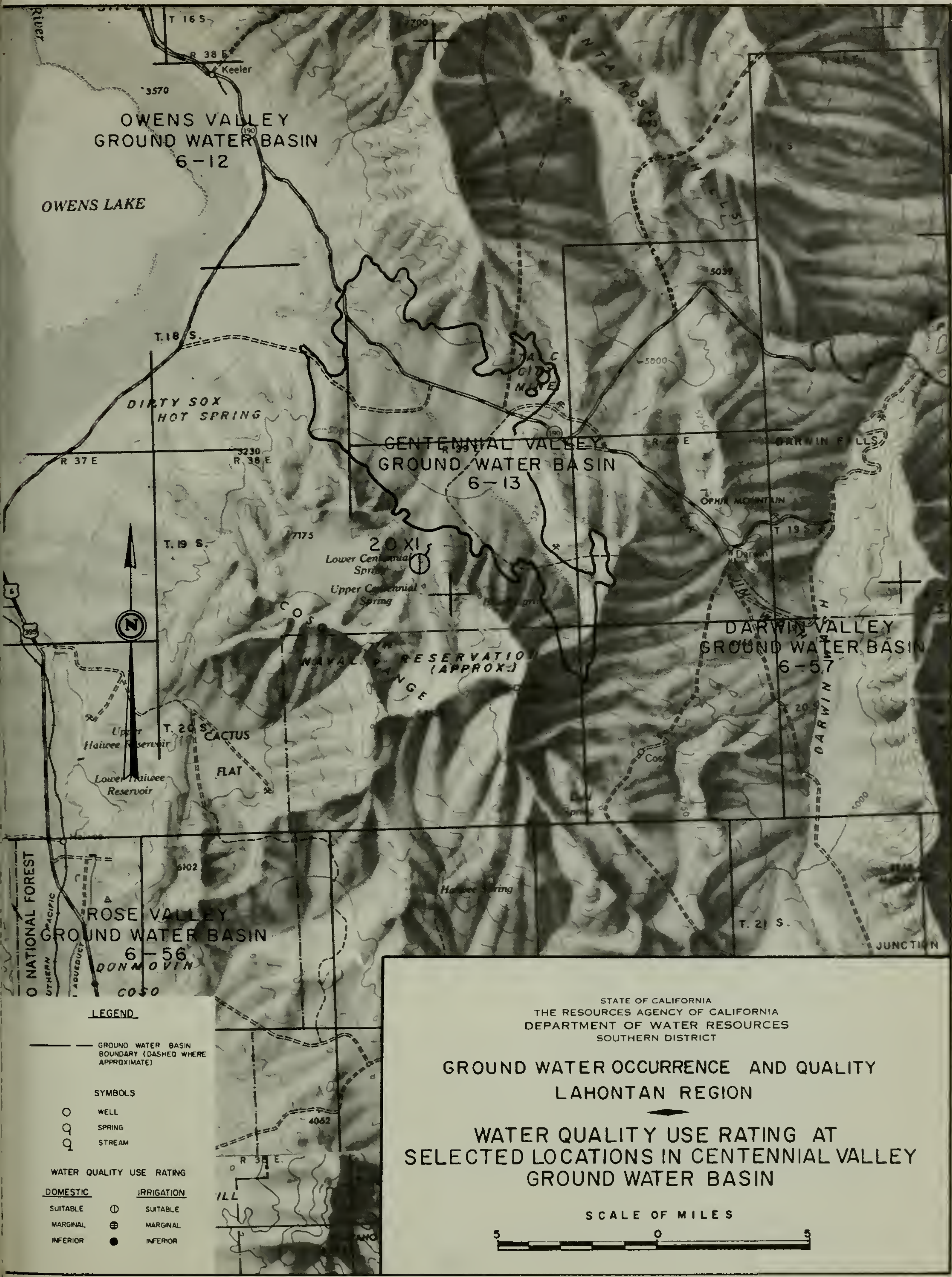
Water Quality. An analysis of water from Lower Centennial Spring (19S-39E-20X1), on the southwest margin of the basin, indicates that this water is calcium-sodium bicarbonate-chloride in character and contains 356 ppm of total dissolved solids. As shown on Table 13, this water is suitable for domestic and irrigation uses.

TABLE 13

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
CENTENNIAL VALLEY GROUND WATER BASIN (6-13)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
19S/39E-20X1	DI						Ca-Na HCO_3-Cl	12-8-54	Flowing	Stock

D - Domestic
I - Irrigation



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WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN CENTENNIAL VALLEY
GROUND WATER BASIN

SCALE OF MILES

5 0 5

COTTONWOOD CREEK DRAINAGE BASIN (NO. 15)

Fish Lake Valley Ground Water Basin (6-14)

Fish Lake Valley Ground Water Basin shown on Figure 6, is a northwesterly trending, long, narrow area of about 68 square miles, located in the eastern part of Mono and Inyo Counties within the Cottonwood Creek Drainage Basin (No. 15). The basin is the southeastern portion of a larger ground water basin which extends across the California-Nevada state line with the greater portion of the basin lying in Nevada.

The California portion of the basin is bounded by the White Mountains on the west and southwest, by the Sylvania Mountains on the south, and by the California-Nevada state line on the north and northeast. The floor of the basin slopes northwesterly from a maximum elevation of 5,600 feet in the southern end to a low of 5,000 feet in the northern end of the basin. White Mountain Peak to the west reaches a maximum elevation of 14,242 feet.

Geology

The White Mountains to the southeast consist of undifferentiated rocks while the Sylvania Mountains to the south and southeast consist of Precambrian and Paleozoic sediments and metasediments and pre-Tertiary granitic rocks. The Quaternary alluvium between the White and Sylvania Mountains extends across the California-Nevada state line. The alluvium, which is exposed over most of the basin floor, comprises the upper portion of the valley fill which extends to a depth of at least 85 feet. Tertiary and/or Quaternary sediments occur in the foothills of the Sylvania and White Mountains. A fault parallels the contact between the Quaternary alluvium and the Tertiary and/or Quaternary sediments occurring in the foothills of the White Mountains.

Water Supply

The principal sources of water supply in the basin are deep penetration of direct rainfall and percolation of stream flow originating in the watershed. Precipitation in the basin ranges from about 10 inches on the basin floor to about 20 inches on the upper peaks of the White Mountains where precipitation occurs mainly as snow.

The estimated mean seasonal natural runoff is about 35,000 acre-feet, most of which is derived from the White Mountains. Gullies, washes, and creeks convey the runoff to the lower part of the basin and thence into Nevada via Fish Lake Valley Wash.

Ground water recharge occurs through the alluvial fans of the Sylvania and White Mountains with Cottonwood Creek, in the White Mountains, being one of the most important recharge areas. Ground water travels northerly, generally paralleling the slope of the land surface; the water table gradient is slightly more than four feet per mile. In the wells shown on Figure 6, depth to ground water ranged from 45 to 88 feet. Usable ground water supplies may be derived from the Recent and underlying older alluvial deposits.

Development and Utilization. The ground water supplies in the basin have been developed mainly for agricultural use. Livestock-watering and domestic use have also required small quantities of ground water. Cottonwood Creek, which flows continuously throughout the year, now supplements the ground water supply. In the past, the creek was the major source of supply for the early settlers.

The combined ground and surface water supplies are used to irrigate approximately 600 areas of hay. Total water use in the ground water basin is estimated to be about 2,000 acre-feet per year.

Water Quality. Mineral analyses of water from five wells indicate that the ground water in the basin is suitable for the established beneficial uses, as shown on Table 14. This water has a total dissolved solids content ranging from 220 to 365 ppm.

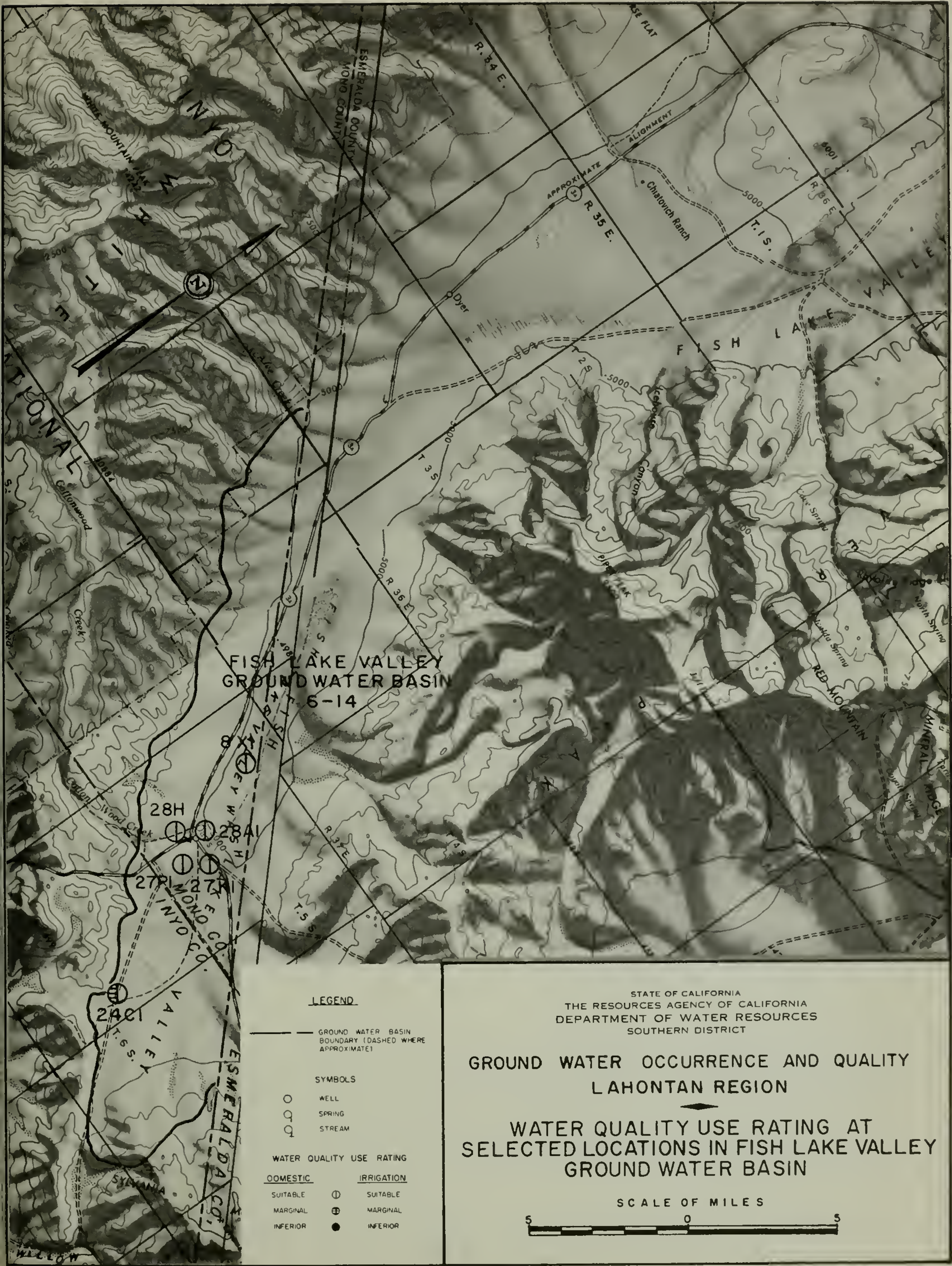
The water from well 6S/37E-24C1, in the southern end of the ground water basin contained 1.1 ppm of fluoride in 1955 and is considered marginal for domestic use. Water from this well is sodium bicarbonate in character; water from other wells is calcium bicarbonate or calcium-magnesium bicarbonate in character. Surface water in Cottonwood Creek is calcium bicarbonate in character; it is of suitable quality for both domestic and irrigation uses.

TABLE 14

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
FISH LAKE VALLEY GROUND WATER BASIN (6-14)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification				Date	feet or cfs	
	Suitable	Marginal	Inferior	Marginal	Inferior					
5S/37E-8X1	DI						Ca-Mg HCO_3	12-9-54	55.2 ft	Stock
Oasis 5S/37E-27K1	DI					4± 1.8	Ca HCO_3			Domestic
5S/37E-27P1	DI						Ca-Mg HCO_3	11-14-56	88 ft	Domestic Irrigation
5S/37E-28A1	DI						Ca HCO_3	6-17-51	45 ft	
Cottonwood Creek 5S/37E-28H	DI					1.2± 1.9	Ca HCO_3	11-18-59	flow	Irrigation
6S/37E-24C1	I	D		F			Na HCO_3	4-19-55	67 ft	Stock

D - Domestic
I - Irrigation



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WATER QUALITY USE RATING AT SELECTED LOCATIONS IN FISH LAKE VALLEY GROUND WATER BASIN

SCALE OF MILES

5 0 5

DEEP SPRINGS DRAINAGE BASIN (NO. 16)

Deep Springs Valley Ground Water Basin (6-15)

Deep Springs Valley Ground Water Basin, shown on Figure 7, is an elongate, northeasterly trending area of about 41 square miles located in the northeastern part of Inyo County within the Deep Springs Drainage Basin (No. 16).

The White Mountains on the north and west, and the Inyo Mountains on the east and south compose the borders of the basin. Elevation of the basin floor ranges from 4,900 feet at Deep Springs Lake to 5,400 feet at the northern end. The Inyo Mountains climb to 8,673 feet and peaks of the White Mountains rise as high as 12,487 feet above sea level. Deep Springs Lake covers about two square miles in the southeast corner of the basin.

Geology

The White Mountains to the north and west and the Inyo Mountains to the south consist of undifferentiated rocks while pre-Tertiary granitic rocks occur in the Inyo Mountains to the east. Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 775 feet. A pressure area exists in the vicinity of Deep Springs Lake which is a moist, salt encrusted type of playa. Fault zones occur along the western and eastern margins of the basin.

Water Supply

The principal source of water supply in the Deep Springs Valley Ground Water Basin is percolation of streamflow originating in the watershed. The annual rainfall for the basin is about seven inches, whereas the annual precipitation on the upper peaks of the White Mountains may be as much as 20 inches.

Birch, Wyman, and Crooked Creeks carry most of the surface runoff from the White Mountains to the west side of the basin. In addition, many other washes and gullies convey runoff to other parts of the basin, but all runoff eventually flows toward Deep Springs Lake. During the wetter months some water may pond on this lake but usually the lake floor is dry.

The basin is recharged at a moderate rate through the fans extending from the base of the White Mountains. The usable ground water supplies are derived from the Recent and underlying older alluvial deposits. Ground water travels in the general direction of the surface slopes, but the hydraulic gradient appears to have a more gradual slope. The presence of springs and artesian flows indicates that a pressure area exists around Deep Springs Lake.

The depth to ground water ranges from 261 feet below the ground surface at the highway maintenance station well (6S/36E-25N1) to artesian flows near Deep Springs Lake. The water table gradient between this well and the lake is about 14 feet per mile.

Development and Utilization. The entire Deep Springs Valley is endowed to the Deep Springs Junior College, which was established in 1917. The college lands cover 45,000 acres of the valley, including the whole ground water basin. In addition, the school has grazing rights on 245,000 acres in the surrounding White-Inyo Mountains. Including the students of the college, the number of residents in the valley is about 25.

Development of ground water supplies has been minor, for streams which flow throughout the year provide plentiful surface supplies. The present utilization of water, about 800 acre-feet per year, is confined to the northern end of the ground water basin, where the state highway maintenance station and the Deep Springs college buildings are located. Wyman and Crooked Creeks provide the main water supply in the basin. This surface water, supplemented with ground water, is used to irrigate approximately 125 acres and to supply a few hundred head of cattle owned by the college.

Water Quality. Ground and surface water supplies in the northern half of Deep Springs Valley Ground Water Basin are suitable for all uses and are calcium bicarbonate in character as shown on Table 15. Two wells (8S/36E-4C1 and -7B1) near the lake in the southern end of the valley produce water in which fluoride concentrations are 1.0 and 1.2 ppm, respectively, and, therefore, are marginal for domestic use. The character of water from these two wells is potassium-sodium bicarbonate and magnesium-calcium bicarbonate, respectively.

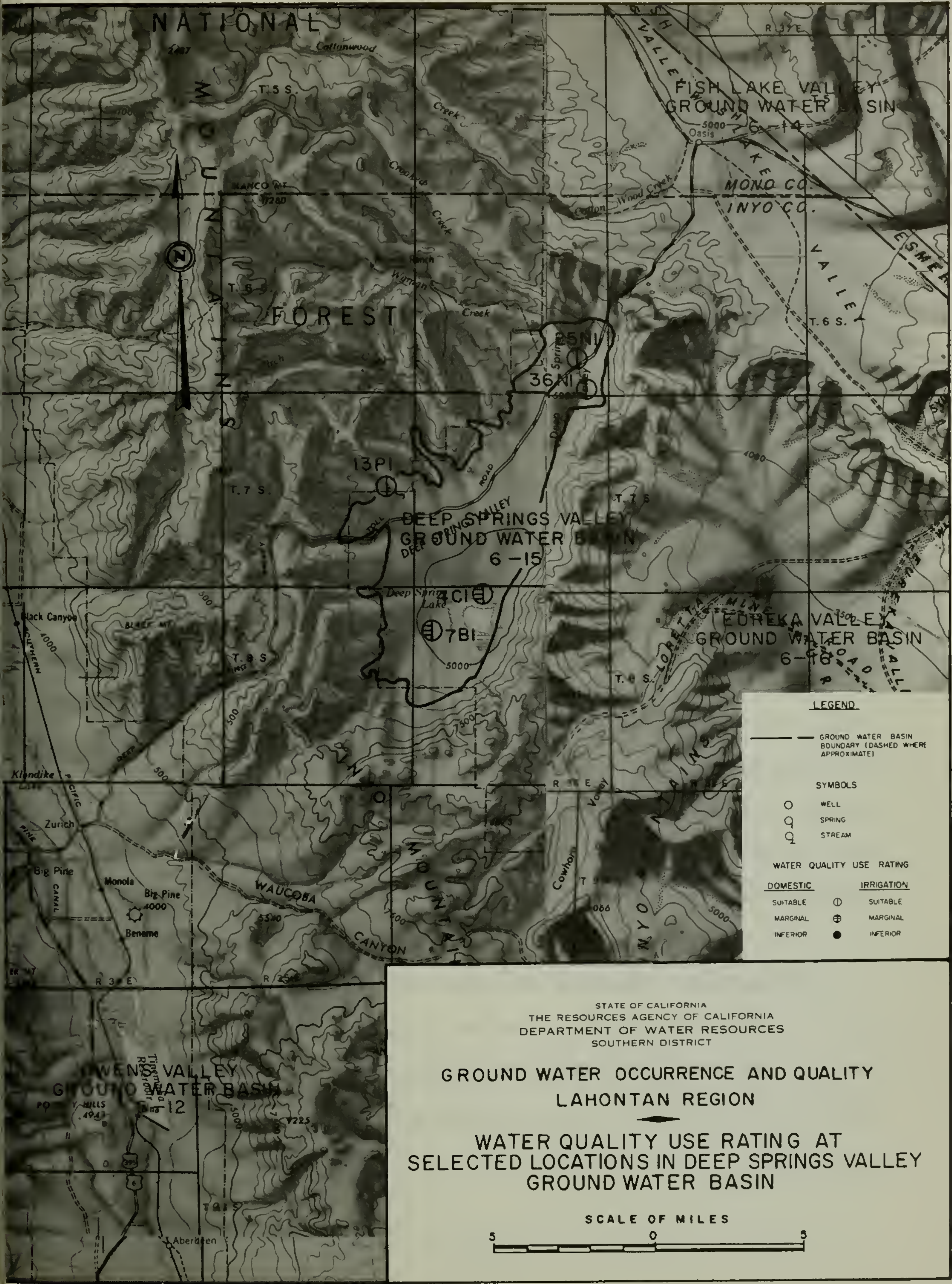
Deep Springs Lake was prospected around 1920 for potassium and sodium salts but was not developed. Recent analyses indicates that waters of the lake contain 84,200 ppm total dissolved solids; water from three shallow holes sunk on the northeast shore of the lake contained a sodium chloride-sulfate brine that had about 200,000 ppm total dissolved solids.

TABLE 15

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
DEEP SPRINGS VALLEY GROUND WATER BASIN (6-15)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
6S/36E-25N1	DI					0 ± 1.6	Ca HCO_3	4-17-61	261 ft	Domestic
6S/36E-36N1	DI						Ca HCO_3			Domestic Irrigation
7S/35E-13P1	DI						Ca-Mg HCO_3	4-20-55	flow	Stock
8S/36E-4C1	I	D		F			K-Na HCO_3	1-25-55	Artesian	None
8S/36E-7B1	I	D		F			Mg-Ca HCO_3			Stock

D - Domestic
I - Irrigation



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GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN DEEP SPRINGS VALLEY GROUND WATER BASIN

SCALE OF MILES

5 0 5

Eureka Valley Ground Water Basin (6-16)

The Eureka Valley Ground Water Basin, shown on Figure 8, occupies a northwesterly trending area of about 156 square miles in the northeastern part of Inyo County within the Deep Springs Drainage Basin (No. 16).

The basin is bordered by the White Mountains on the north, the Sylvania Mountains on the northeast, the Last Chance Range on the east and southeast, and the Inyo Mountains on the west and southwest.

Elevation of the basin floor ranges from 2,880 feet at Eureka Dry Lake in the southern end to about 4,200 feet in the northern end of the basin. The margins of the basin merge with the surrounding mountains where many peaks rise to elevations of 7,000 feet or more above sea level. Eureka Lake is about 1.4 square miles in area.

Geology

Pre-Tertiary granitic and undifferentiated rocks occur in the White Mountains while Precambrian and Paleozoic sediments and metasediments predominate in the Sylvania Mountains to the northeast and the Last Chance Range to the east and southeast. The Inyo Mountains to the west and southwest are composed of pre-Tertiary granitic and undifferentiated rocks and Tertiary-Quaternary volcanic rocks.

Quaternary alluvium is exposed over most of the basin floor, comprising the upper portion of the valley fill, which extends to a depth of at least 640 feet. Large sand dunes, rising as high as 500 feet above the basin floor, occur in the southeast corner of the basin near Eureka Lake, a dry type of playa.

Water Supply. The principal source of ground water replenishment in the Eureka Valley Ground Water Basin is percolation of streamflow originating in the watershed. Annual precipitation in the basin ranges from about five inches on the valley floor to a maximum of ten inches on the surrounding mountains. Numerous washes convey the resultant runoff to the central part of the basin where it is channeled southeast toward Eureka Lake. Willow Creek, although usually dry, probably carries the greatest amount of runoff.

Usable ground water supplies are derived from the Recent and underlying older alluvial deposits. The upper slopes of the basin are considered the recharge areas. In these areas, surface water percolates to the ground water storage area at a moderate rate, and ground water probably moves from these recharge areas toward the southern end of the basin. Ground water moving southeasterly may also flow to the Saline Valley which lies to the southwest at an elevation of 1,059. Depth of water at well 9S/38E-11L1 is about 380 feet.

Development and Utilization. At present, there is no known utilization of ground water in this basin. One well (9S/38E-11L1), now abandoned and unusable, was apparently developed for use in the earlier mining activities in the surrounding mountains. Mining operations still exist along the east and west sides of the basin, but probably fewer than 15 people reside in the area.

Water Quality. No data are available on quality of ground water in the basin. However, one analysis has been made for Willow Springs (7S/39E-16Q1) which is in the mountains near the northeast part of the basin.

Water from this spring has a calcium bicarbonate character and a total dissolved solids content of 554 ppm. As shown on Table 16, the water is suitable for all uses; it is conveyed to the basin via Cucomungo Canyon, a tributary to Eureka Valley.

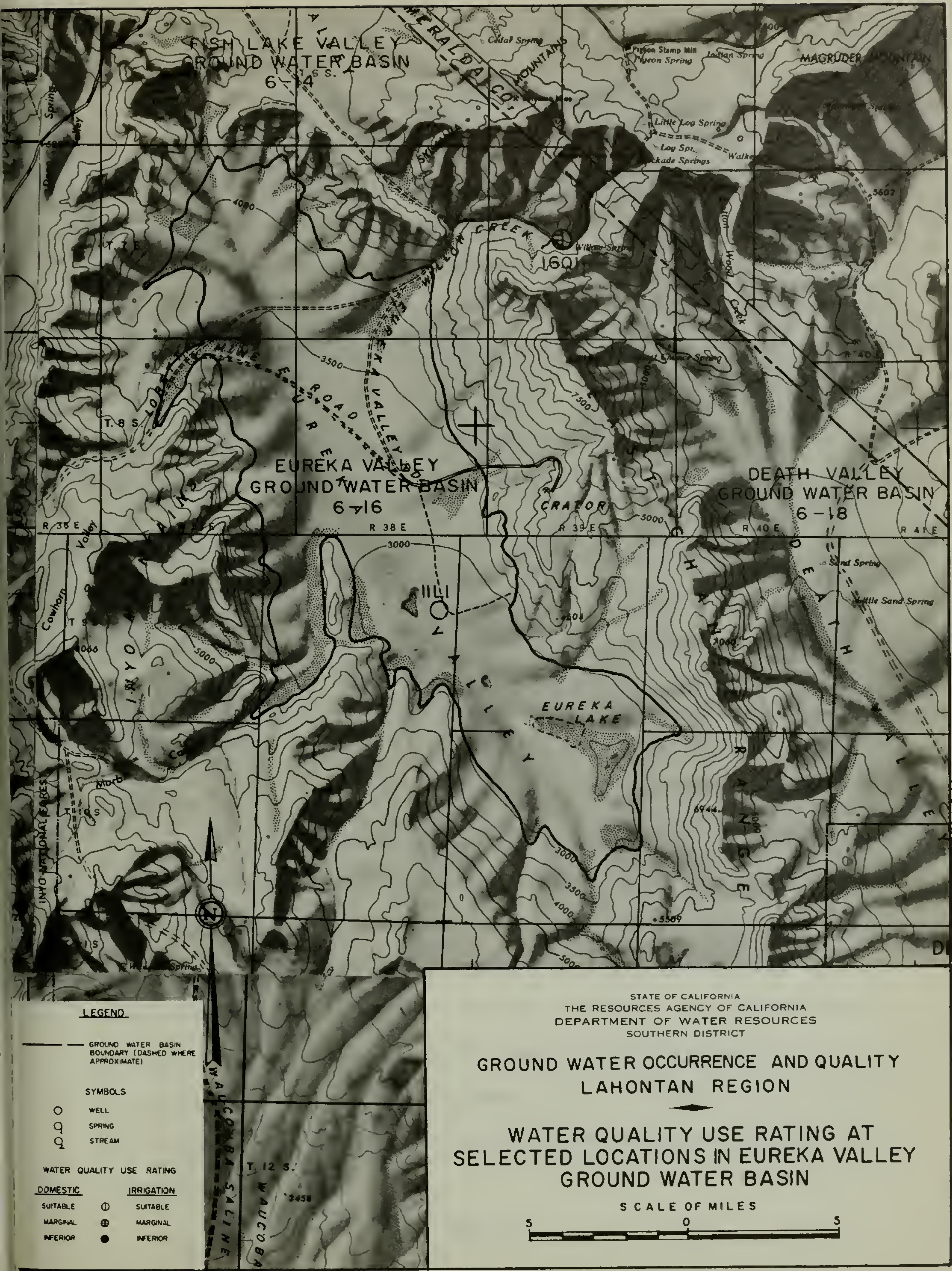
TABLE 16

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
EUREKA VALLEY GROUND WATER BASIN (6-16)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Water Quality Use Rating: Classification: Marginal	Water Quality Use Rating: Classification: Inferior	Water Quality Use Rating: Basis for Classification: Marginal	Water Quality Use Rating: Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
7S/39E-16Q1	DI						Ca HCO_3	4- 8-54	flow	Domestic
9S/38E-11L1								3-12-55	379 ft	Abandoned

D - Domestic
I - Irrigation

FIGURE 8


STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN EUREKA VALLEY
GROUND WATER BASIN
SCALE OF MILES
5
0
5
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
SUITABLE
MARGINAL
MARGINAL
INFERIOR
INFERIOR
FISH LAKE VALLEY
GROUND WATER BASIN
6-14
EUREKA VALLEY
GROUND WATER BASIN
6-16
DEATH VALLEY
GROUND WATER BASIN
6-18
16Q1
11L1
EUREKA LAKE
MAGRUDER MOUNTAIN
Pigeon Stamp Mill
Pigeon Spring
Indian Spring
Cedar Spring
Little Log Spring
Log Spr.
Walker
Willow Spring
WILLOW CREEK
EUREKA VALLEY ROAD
CRATOR
Sand Spring
Little Sand Spring
LAST CHANCE RANGE
DEATH VALLEY
INYO MOUNTAINS
Cowhorn
Valley
INYO NATIONAL FOREST
WAUCOBA SALINE
WAUCOBA
EUREKA VALLEY
T. 8 S.
T. 12 S.
R 36 E
R 38 E
R 39 E
R 40 E
R 41 E
3000
3500
4000
5000
7500
5602
6944
5509
3458

Saline Valley Ground Water Basin (6-17)

Saline Valley Ground Water Basin, shown on Figure 9, is a predominately northwesterly trending irregularly shaped area of about 211 square miles in the central western part of Inyo County, near the southern end of the Deep Springs Drainage Basin (No. 16).

It is bordered by the Saline Range and the Last Chance Range on the north and northeast, the Panamint Range on the east, the Nelson Range on the south, and the Inyo Mountains on the west. Salt Lake covers an area of 19 square miles in the southwestern part of the basin. This lake is located in the lowest part of the basin and usually contains ponded water.

Elevation of the basin floor ranges from 1,059 feet at Salt Lake to about 5,000 feet at the northern end of the basin area. Most peaks in the bordering mountains average about 6,500 feet in elevation, but some peaks in the rugged Inyo Mountains attain elevations of more than 11,000 feet.

Geology

Paleozoic sediments and Quaternary volcanic rocks predominate in the Saline Range to the north. Precambrian and Paleozoic sediments and metasediments occur in the Last Chance Range to the north and northeast. Similar type rocks and pre-Tertiary granitic rocks occur in the Panamint Range to the east. The western and southern limits of the basin generally coincide with a well-defined series of faults occurring along the base of the Inyo Mountains and Nelson Range. The Inyo Mountains and Nelson Range consist largely of Paleozoic sediments and pre-Tertiary granitic rocks.

Quaternary alluvium, which is exposed over much of the basin floor, comprises the upper portion of the valley fill. Quaternary dune sand deposits occur along the northwest and southeast periphery of Salt Lake, a moist salt encrusted type of playa.

Water Supply

The principal source of ground water replenishment in the Saline Valley Ground Water Basin is percolation of streamflow originating in the watershed. Annual precipitation ranges from about four inches on the basin floor to as much as 12 inches on the Inyo Mountains. Runoff from the surrounding mountains flows down gullies and washes onto the basin floor. Waucoba Wash, whose headwaters originate in the mountains along the northern edge of the basin, carries runoff to Salt Lake during periods of heavy runoff.

Recharge to the ground water basin occurs at a moderate to high rate in the higher parts of the basin. The area underlying Waucoba Wash is one of the most important recharge areas of the basin. Usable ground water supplies are derived from the Recent and underlying older alluvial deposits.

Ground water flows from the upper slopes to the basin floor in a path which approximates the slope of the land surface. Water level measurements indicate that some ground water may travel into Saline Basin as subsurface inflow from nearby Eureka Valley Ground Water Basin.

Development and Utilization. Development in Saline Valley basin has been slow because of difficult access to the basin. Early development of the valley originated about 1903 with mining of saline deposits. Salt production from these deposits increased until 1913, but decreased thereafter and ceased in 1954. Runoff from Hunter Canyon provided the major supply of water used in making brine from the saline deposits, but minor quantities of ground water were also used.

Spring water, and runoff from the surrounding mountains, principally from Willow Creek, are the only known present sources of water for domestic use.

Water Quality. Mineral analyses indicate that much of the ground water in the Saline Valley Ground Water Basin is of inferior quality, as shown on Table 17. Analyses of water from Lower Warm Springs (13S/39E-18Q1) indicate that this supply would be inferior for domestic use because of its high fluoride concentration. Well (14S/38E-35M1) south of Salt Lake contains water that has a total dissolved solids content of 3,765 ppm; this water also would be inferior for domestic and irrigation uses.

Most surface water in the basin is of poor quality as well. Only water from Addie Gulch (12S/37E-6J), in the extreme northwestern tip of the basin, proved suitable for all purposes. The total dissolved solids content of this water was 252 ppm. Willow Creek is inferior for domestic use because it has a high fluoride concentration. Salt Lake contains 315,000 ppm total dissolved solids or about nine and one-half times as much as sea water.

TABLE 17

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
SALINE VALLEY GROUND WATER BASIN (6-17)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
Lower Warm Spring 13S/39E-18Q1		I	D	B, % Na	F		Na HCO_3 SO_4	3- 8-55	flow	Wildlife
14S/38E-35M1			DI		Cl, B, TDS EC, % Na SO_4		Na Cl	1-26-55	38.3 ft	Abandoned
Addie Gulch 12S/37E-6J	DI						Ca HCO_3	4- 8-53	flow	Unknown
Willow Creek 13S/37E-2Q	I		D		F	5.5± 2.9	Na HCO_3	11-19-59	flow	Mining Domestic
Salt Lake 14S/38E-26F			DI		EC, TDS, % Na B, Cl, SO_4		Na Cl	3- 8-55	surface	Mining

D - Domestic
I - Irrigation


SALINE VALLEY
GROUND WATER BASIN
6-17
18Q1
26F
35M1
EUREKA LAKE
SALINE RANGE
PANAMINT RANGE
WAUCOBA WASH
VALLEY
R. 37 E.
R 38 E.
R 39 E.
R. 41 E.
T 12 S.
T 13 S.
T 14 S.
INYO NATIONAL
Salt Lake
Lower Warm Spring
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
SUITABLE
MARGINAL
MARGINAL
INFERIOR
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN SALINE VALLEY
GROUND WATER BASIN
SCALE OF MILES
5
0
5

AMARGOSA RIVER DRAINAGE BASIN (NO. 17)

Death Valley Ground Water Basin (6-18)

Death Valley Ground Water Basin, shown on Figure 10, extends southeasterly from the California-Nevada state line through the northwestern part of Inyo County into northern San Bernardino County. This basin, which has an area of about 1,316 square miles, is approximately 150 miles long and extends almost the entire length of the Amargosa River Drainage Basin (No. 17).

The basin is bordered by the Grapevine, Funeral, Black, and Ibex Mountains of the Amargosa Range on the east and the Avawatz Mountains on the south. To the west is the Panamint Range which includes the Owlshead and Cottonwood Mountains, and the Last Chance Range.

These bordering mountains rise to elevations of 5,000 to 11,000 feet; Telescope Peak in the Panamint Range is 11,049 feet above sea level. The basin floor ranges from 282 feet below sea level at Badwater to 4,000 feet above sea level in the northern end of the basin. Death Valley Lake is an elongate playa lake which occupies the southern part of the basin. Some 40 miles long, this lake has an area of about 176 square miles.

Geology

A wide variety of rocks, ranging in age from Precambrian to Recent, occur in the basin and surrounding highlands. The mountains of the Amargosa Range to the east, the Avawatz Mountains to the south, and the Panamint Range to the west consist largely of Precambrian and Paleozoic sediments and metasediments, pre-Tertiary metamorphic and granitic rocks, Tertiary volcanic rocks, and Tertiary sediments.

Quaternary alluvium, which is exposed over a portion of the basin floor, comprises the upper portion of the valley fill. Sand dunes rising as high as 50 feet occur in the Mesquite Flat area north of Death Valley Lake, a moist, salt encrusted type of playa. This dry lake is the largest playa in the Lahontan Region and forms an extensive salt flat.

Death Valley is a tremendous depressed fault block, or graben. Northwesterly trending faults associated with the graben may act as barriers to ground water movement.

Water Supply

The principal source of water supply in the basin is percolation of streamflow originating in the watershed. Precipitation in the basin area ranges from about two inches per year on the basin floor to 12 inches per year on the upper peaks of the Panamint Range. Frequently, cloudbursts produce as much as a half-inch of precipitation in a few minutes.

Runoff from precipitation on mountain and lowland areas in all parts of the ground water basin flows toward the central axis of the basin and then toward Badwater. Runoff from the northern end of the ground water basin is carried southward by Death Valley Wash which joins Salt Creek. In seasons of heavy precipitation this creek carries runoff to Badwater. The infrequent surface runoff from the southern end of Death Valley is conveyed northward to Badwater by the Amargosa River. Even though the surface flow in this portion of the river is sporadic, there appears to be almost continuous subsurface flow in the sediments underlying its course.

Usable ground water supplies are derived from the Recent and underlying older alluvial deposits. Recharge occurs at moderate to high rates through the alluvial fans along the margins of the basin. Subsurface inflow from the nearby Valjean Valley Ground Water Basin provides additional recharge to the Death Valley Ground Water Basin. It is believed that Wingate Basin may also be a source of subsurface inflow to Death Valley Basin. All recharge moves toward Badwater.

Development and Utilization. Development of Death Valley resulted principally from the discovery and subsequent mining of borax and other mineral deposits. The famous "Twenty Mule Teams" hauled borax from Death Valley during the 1880's, but mining was discontinued when higher grade and more easily treated deposits were discovered at other readily accessible sites.

Nevertheless, Death Valley has continued to attract tourists, and public interest in the historical features of the area led to the establishment of the Death Valley National Monument in 1933. That portion of the basin included within the borders of the national monument is unavailable for private development.

The largest water user in the basin is the Furnace Creek Ranch. Water for irrigation and domestic use at the ranch is obtained from Texas Springs and Furnace Creek Wash. Scotty's Castle, a major tourist attraction, obtains water from springs in Grapevine Canyon. At the Stovepipe Wells Hotel, springs provide water for drinking but a well provides water for other domestic needs.

In 1958, 43 acres of dates and pasture were the only irrigated crops. This represented a decrease from acreage irrigated in 1905 when more than 100 acres of alfalfa were irrigated. Since 1958, there has been no significant change in the amount of irrigated acreage.

The estimated annual irrigation and domestic use of water in the basin is 1,000 acre-feet. Furnace Creek Wash provides a surface flow of about 4,100 acre-feet per year. However, much of the flow in the Furnace Creek Wash and in the other areas is lost for beneficial uses by evaporation, evapotranspiration, or by seepage.

The water supplies of this basin are used by permanent residents, who number about 75. Additional water supplies are used seasonally by hundreds of visitors and tourists who frequent the Death Valley resorts during the winter months.

Water Quality. Mineral analyses of water samples from several sources in Death Valley indicate that the majority are of inferior quality for domestic and irrigation purposes, as shown on Table 18. The most significant water quality problem is the high fluoride concentrations, but high boron concentrations also constitute a serious problem. Fluoride concentrations range from 0.10 to 7.5 ppm with a mean of 2.19 ppm and boron concentrations range from 0.02 to 11.9 ppm, with a mean of 0.93 ppm.

Ground water supplies from the northeast part of the basin and from springs in the Furnace Creek Wash area are predominantly sodium bicarbonate in character. The total dissolved solids content of the water sources increases continuously from north to south in the basin. Between Grapevine Canyon (11S/43E-5E1) and Stovepipe Wells (15S/45E-15D1), the total dissolved solids content ranges from 575 to 2,250 ppm; springs in the Furnace Creek Wash area contain about 700 ppm of total dissolved solids.

The presence of high fluoride and high boron concentrations and high percent sodium in these ground water supplies result in their classification as marginal or inferior.

Water from springs in the Furnace Creek Wash area is marginal for irrigation use but is suitable for crops, such as dates or pasture, which are more tolerant to boron and sodium.

Springs in Emigrant Pass area in the west central portion of the basin supply water of suitable quality, containing about 300 ppm total dissolved solids. Most of these springs contain magnesium-calcium bicarbonate waters that are suitable for both domestic and irrigation uses. Ground water extracted from a well (13S/33E-36K1) at the Stovepipe Wells Hotel, a few miles north of Emigrant Springs and is sodium chloride in character, is inferior for domestic and irrigation purposes because it contains 4,421 ppm total dissolved solids. In the southern half of Death Valley, ground water supplies are of inferior quality. However, Bennet's Well (24N/1E-21X1), a developed spring, provides water which is suitable for all purposes.

Generally the quality of these ground water supplies was impaired when the water, as it moved through saline sediments and salt deposits, dissolved excessive amounts of salts. Some surface water supplies, including Salt Creek and the Amargosa River, accumulate salts as they flow through saline deposits on their way toward Badwater. Analyses of water samples from these streams indicate that total dissolved solids range from 4,000 to 12,000 ppm. At Badwater, such ground water contains as much as 40,000 ppm.

TABLE 18

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
DEATH VALLEY GROUND WATER BASIN (6-18)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Last Chance Spr. 8S/39E-2K1	I	D		F			Mg HCO_3	4-12-52	Flow	Domestic
Mesquite Spr. 11S/42E-26R1			DI	B	F, % Na	5.1 ± 2.0	Na HCO_3	12- 9-59	Flow	Domestic
11S/43E-5E1			DI	B	F, % Na		Na HCO_3	12- 9-59	Flow	Domestic
Midway Well 14S/45E-18D1			DI	TDS, EC	F, B		Na HCO_3	-	-	Domestic
Stovepipe Wells 15S/44E-36K1			DI		% Na, F EC, TDS, B		Na Cl	4-20-61	100 ft	Domestic
Stovepipe Well 15S/45E-15D1			DI	F, SO_4	% Na EC, TDS, B		Na HCO_3-SO_4	-	-	Domestic
L. Emigrant Spr. 27S/44E-7X1	DI						Mg-Ca HCO_3	12-21-53	Flow	Domestic
U. Emigrant Spr. 27S/44E-28X1	DI						Mg-Ca HCO_3	12-10-59	Flow	Domestic
Canyon Spr. 27S/44E-34X1	DI						Mg-Ca HCO_3	4- 9-55	Flow	Domestic
Warm Spr. 23S/47E-5X1	DI						Ca SO_4	4- 8-52	Flow	Domestic

D - Domestic
I - Irrigation

TABLE 18

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
DEATH VALLEY GROUND WATER BASIN (6-18)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	feet or cfs	Use
Sheep Cr. Spr. 17N/6E-5Q1	I	D		F, SO_4			Mg-Na SO_4	3-11-53	Flow	Mining Domestic
Owle Hole Spr. 18N/3E-22C1			DI	Cl, SO_4, TDS, EC	F, B, % Na		Na Cl-SO_4	6-15-53	Flow	Mining
Saratoga Spr. 18N/5E-2E1			DI		F, B, % Na, SO_4 TDS, EC, Cl	<140 (α, β)	Na Cl-SO_4	12-22-55	Flow	Domestic
Salt Spring 18N/7E-30D1			DI		EC, SO_4, Cl, F, B, TDS, %Na	7.9 ± 0.9	Na Cl	1-14-18 4-21-54 5- 9-61	Flow Flow Dry	Unused
19N/5E-32Z1			DI		F, B, %Na, SO_4 TDS, EC, Cl		Na Cl	9-23-54	0.5±	Unused
Gravel Well 23N/1E-23X1			DI	B, % Na	EC, TDS, Cl	4.8 ± 1.9	Na Cl	---	--	Domestic
Bennetts Well 24N/1E-21X1	DI					0.0 ± 1.7	Ca-Na Cl-HCO_3	---	--	Domestic
Cow Spr. 27N/1E-3A1		I	D	% Na	F		Na HCO_3	4- 8-55	Flow	Domestic
Texas Spring 27N/1E-23B1		I	D	% Na, B	F	4.4 ± 1.8	Na HCO_3	12-10-59	Flow	Domestic Irrigation
Travertine Spr. 27N/1E-26A1		I	D	% Na	F		Na HCO_3	4-22-54	Flow	Domestic

D - Domestic
I - Irrigation

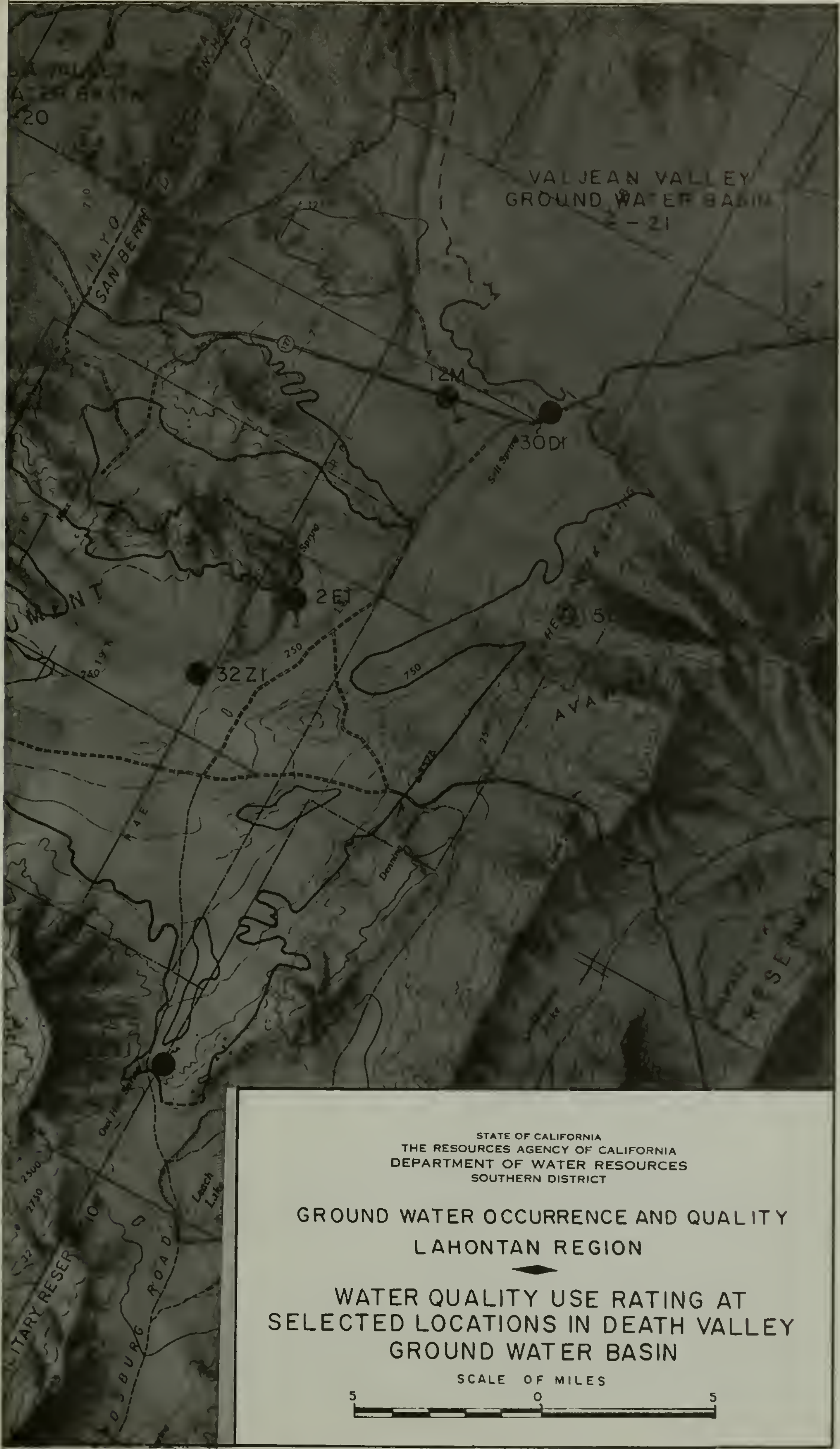
TABLE 18

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
DEATH VALLEY GROUND WATER BASIN (6-18)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Neveres Spr. 20N/1E-36G1		I	D	SO_4,B, % Na	F	30 (β, α)	Na HCO_3	11-29-56	Flow	Domestic
Keane Spring 30N/1E-BE1	DI				F		Na-Ca HCO_3-SO_4	4-12-56	Flow	Domestic
Salt Creek 16S/46E-14Q			DI	F	TDS, EC, B Cl,SO_4,%Na	87.9 ± 3.3	Na Cl	12-10-59	Flow	None
Amargosa River (surface) 18N/6E-12M			DI		%Na, TDS,EC, F,B,SO_4,Cl		Na Cl	4-11-53	Flow	None
Bad Water Lake 25N/2E-31			DI		%Na, TDS, EC, F,B,SO_4,Cl		Na Cl	2- 6-58	Surface	None

D - Domestic
I - Irrigation

FIGURE 10



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SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN DEATH VALLEY
GROUND WATER BASIN

SCALE OF MILES
5 0 5

LEGEND

GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)

SYMBOLS

- WELL
- SPRING
- STREAM

WATER QUALITY USE RATING

DOMESTIC		IRRIGATION
SUITABLE		SUITABLE
MARGINAL		MARGINAL
INFERIOR		INFERIOR

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SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN DEATH VALLEY GROUND WATER BASIN

SCALE OF MILES
5 0 5

Wingate Valley Ground Water Basin (6-19)

Wingate Valley Ground Water Basin, shown on Figure 11, occupies a northeasterly trending irregularly-shaped area of about 66 square miles. The main portion of the basin is in San Bernardino County, with a very small portion extending northward into Inyo County; the basin lies within the Amargosa River Drainage Basin, No. 17.

The basin is bordered by the Panamint Range on the north, the Owlshead Mountains on the east, the Quail Mountains on the south, and Brown Mountain and adjoining peaks on the west. Elevation of the basin floor ranges from 1,700 feet in the northeastern end to 3,300 feet in the southern end of the basin. Elevations in the surrounding mountains rise to over 5,000 feet.

Geology

Tertiary volcanic rocks and Tertiary-Quaternary sediments occur to the north and northwest in the Panamint Range with pre-Tertiary granitic and Tertiary volcanic rocks occurring in the Owlshead Mountains to the east. The Quail Mountains to the south and Brown Mountain to the west consist predominately of Tertiary volcanic rocks. Other peaks on the west consist of Tertiary-Quaternary volcanic rocks. Quaternary alluvium, which is exposed over much of the basin floor, comprises the upper portion of the valley fill.

Water Supply

The sources of ground water replenishment to the basin are deep penetration of direct precipitation and percolation of streamflow originating in the watershed. It is estimated that the annual precipitation in this basin is less than five inches. Most of the runoff from the relatively small drainage area flows easterly towards Death Valley through Wingate Wash which traverses the basin.

Recharge occurs on the upper slopes of the basin at a moderate to high rate. Ground water probably moves northeasterly from the recharge areas following the hydraulic gradient towards Death Valley. Usable ground water supplies may be derived from the Recent and underlying older alluvial deposits.

Development and Utilization. Most of the Wingate Valley Ground Water Basin underlies a naval reservation, presently restricted for military use only. Prior to establishment of the naval reservation, mining was the only activity in the basin. Gypsum deposits were mined in the early 1900's and water hauled from Hidden Springs (26S/47E-20Q1) provided the water supply for these mining operations. At present this spring is the only source of ground water in the basin.

Water Quality. Water from Hidden Springs has a fluoride concentration of 1.2 ppm and, therefore, is marginal for domestic purposes, as shown on Table 19. The water contains 656 ppm of total dissolved solids and is sodium chloride-bicarbonate in character.

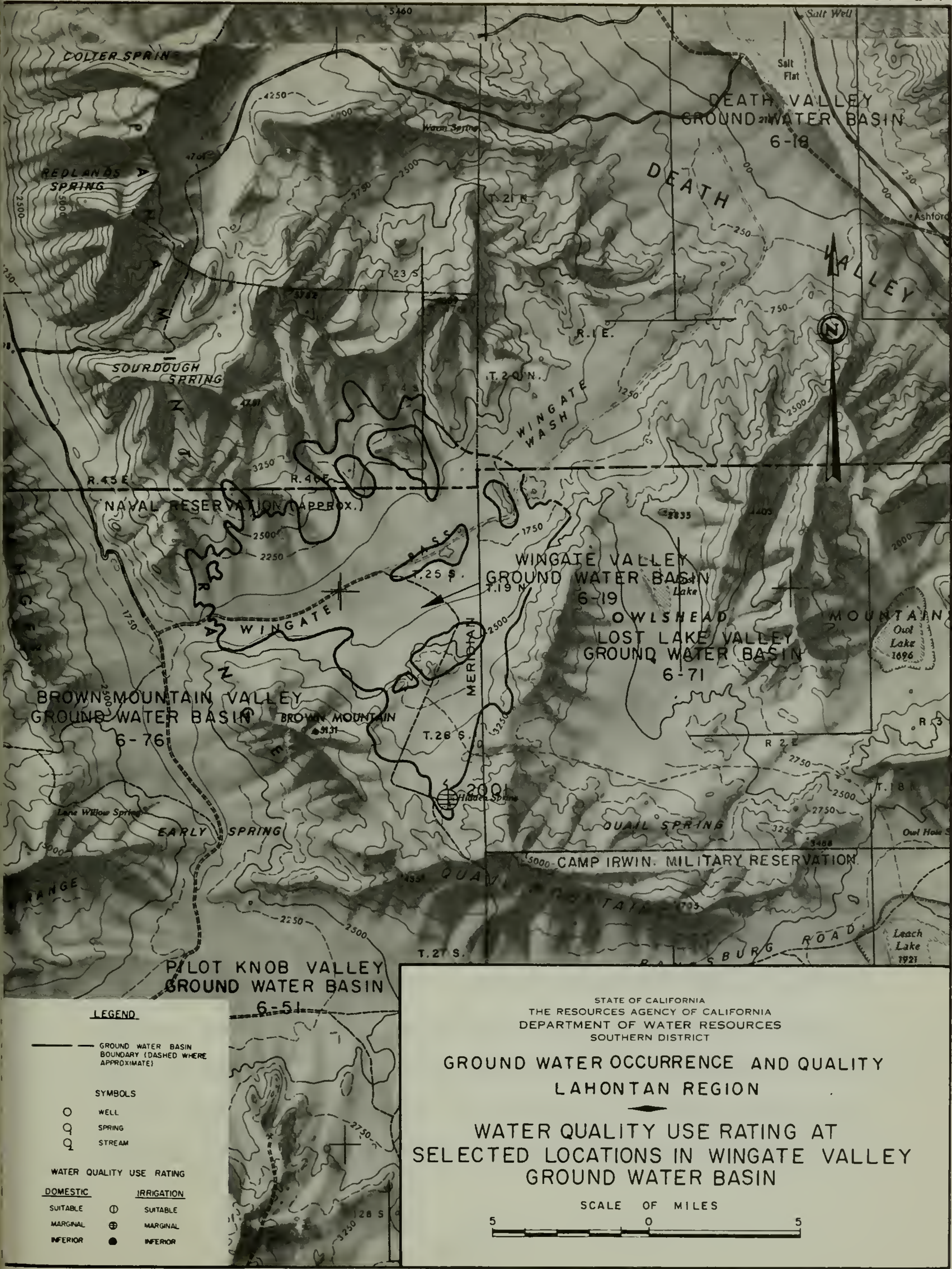
TABLE 19

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
WINGATE VALLEY GROUND WATER BASIN (6-19)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
Hidden Springs 26S/47E-20Q1		DI		F, % Na, B			Na Cl-HCO_3	6-16-53	flow	unused

D - Domestic
I - Irrigation

FIGURE 11



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SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN WINGATE VALLEY GROUND WATER BASIN

Amargosa Valley Ground Water Basin (6-20)

Amargosa Valley Ground Water Basin, shown on Figure 12, is a northwesterly trending irregular area of about 615 square miles in southeastern Inyo County within the Amargosa River Drainage Basin (No. 17). The ground water basin extends across the California-Nevada state line, encompassing an additional area of 719 square miles in Nevada.

The basin is bordered by the Resting Spring and Nopah Ranges on the east; the Dumont Hills on the south; and the Greenwater Range, the Ibex, Black, and Funeral Mountains on the west. Although the basin extends into Nevada, for the purposes of this report, the California-Nevada state line is considered to be the northeastern border.

The floor of the basin ranges in elevation from about 1,300 feet south of Tecopa to 2,300 feet near the intersection of the Amargosa River and the California-Nevada state line. Pyramid Peak in the Funeral Mountains rises to an elevation of 6,725 feet above sea level.

Geology

The Resting Spring and Nopah Ranges to the east consist predominantly of Precambrian and Paleozoic sediments and metasediments. Pre-Tertiary metamorphic and Tertiary volcanic rocks also occur in the southern part of these ranges. To the south, the Dumont Hills and their westerly extension consist largely of Tertiary and/or Quaternary sediments, plus a variety of other rock types, including pre-Tertiary granitic and Tertiary volcanic rocks. To the west, the Funeral Mountains consist of Precambrian and Paleozoic sediments and metasediments, and pre-Tertiary metamorphic rocks; the Greenwater Range consists of Tertiary volcanic rocks and sediments with some pre-Tertiary granitic rocks; and the Ibex Mountains consist of Pre-cambrian and Paleozoic sediments and metasediments, pre-Tertiary meta-morphic rocks, and Tertiary volcanic rocks.

Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill, which extends to a depth of at least 900 feet. Quaternary lake deposits in the vicinity of Shoshone and Tecopa have been eroded and dissected into a badland to-pography. Quaternary playa deposits crop out locally. The Furnace Creek fault zone, a major structural feature, roughly corresponds to the north-westerly trending axis of the basin.

Water Supply

The principal sources of water supply in the basin are deep pene-tration of direct precipitation and percolation of streamflow originating in the watershed. The ground water basin receives about four inches of precipitation each year. Most of this percolates into the alluvium, resulting in little surface runoff. The surface runoff resulting from in-frequent rainstorms or flash floods usually flows toward the channel of the Amargosa River which trends southeasterly through the basin, from the California-Nevada state line to the Valjean Valley Ground Water Basin, to the south.

The basin is largely recharged through the alluvial fans of the bordering mountains. Most of these fans consist of material that generally is capable of absorbing recharge at a moderate rate.

Ground water may be extracted from the Recent and underlying older alluvial deposits. Ground water travels southeasterly through the basin, generally following the course of the Amargosa River. Ground water flows from Nevada into the northeastern part of the basin and thence southward toward Valjean basin. Movement of ground water is probably restricted and runoff is partially ponded at times near Eagle Mountain, which is situated close to the center of the valley.

Depth to ground water ranges from several hundred feet to flowing conditions. Growth of phreatophytes along the channel of the Amargosa River (where the river crosses the California-Nevada state line) indicates that the ground water table is near the surface in the area. Several areas near Shoshone and Tecopa Hot Springs are covered with lush plant growth; this growth indicates that ground water occurs at shallow depths. Near Shoshone, surface flow of ground water has been observed.

Development and Utilization. Development of the valley began with mining activities in the late 1800's which continued to the early 1900's. Mining gave impetus for the building of towns, such as Ryan, Greenwater, and Furnace. However, these towns were occupied for only a short time because mining activities were sporadic. Water supplies for the residents of these towns were obtained from springs and shallow wells. Water for processing of borax at the Amargosa borax works (operated 1882 to 1890, two miles west of Tecopa Hot Springs) was obtained from two artesian wells.

In the southern part of the basin, ranches at Resting Springs, Yeoman Hot Springs (Chappo Springs), and China Ranch, obtained continuous flowing water from springs. Spring water was also used for domestic irrigation at Shoshone. In Chicago Valley, irrigation operations were unsuccessful; although ground water was found at relatively shallow depths, its quality was unsuitable for irrigation uses.

The estimated quantity of ground water extracted from the wells and springs in the basin annually is about 1,500 acre-feet. This quantity supplies the requirements of about 650 people, most of whom live near or in Shoshone and Tecopa.

Water Quality. Ground water in the Amargosa basin generally is marginal to inferior in quality, as shown on Table 20, because of the relatively high concentrations of fluoride and boron, and percent sodium which exceed the limits for these constituents. Throughout the basin ground water contains fluoride concentrations which exceed the permissible limits for domestic use. High boron concentrations occur in ground water in the area from Shoshone to Tecopa. Sodium is present at a high percent in ground water obtained along the drainage course of the Amargosa River.

The total dissolved solids content of ground water ranges from about 490 ppm to about 2,300 ppm. The latter high concentration was measured in water from Tecopa Hot Springs, which also contained about 0.2 parts per million arsenic, or about four times the maximum permissible limit for public domestic supplies.

The mineral content increases in waters obtained along the Amargosa River from north to south. Evaporation of shallow ground water results in the accumulation of salts in the ground water and in the near-surface sediments. Flood waters may transport these salts farther down the river channel from the area of deposition, impairing ground water farther downstream. In the drainage system of the river there are also areas which contain salt and gypsum beds, which provide additional quantities of minerals and further impair water quality. Lake beds in the vicinity of Tecopa contain layers of salt which runoff water or percolating ground water may dissolve. Minerals in these deposits may also be dissolved by flood waters and transported by the flood waters downstream to other areas.

The character of ground water in the basin varies. At Death Valley Junction ground water is sodium bicarbonate, whereas at Shoshone and Tecopa, ground water is sodium bicarbonate-sulfate. Along the margins of the basin ground water supplies contain more calcium and magnesium than sodium.

TABLE 20

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
AMARGOSA VALLEY GROUND WATER BASIN (6-20)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification			Water Quality Use Rating: Basis for Classification		Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
20N/7E-4R1			DI	TDS, EC, SO_4	% Na, F, B		Na HCO_3-SO_4	3-21-61	flow	Domestic
Tecopa -10M1			DI	% Na	F, B	9.8 ± 2.0	Na HCO_3-SO_4			Municipal
21N/7E-6M1			DI	SO_4, TDS, EC	% Na, F, B	2.1 ± 2.0	Na SO_4-HCO_3	12-11-59	2.0 ft	Domestic
Tecopa Hot Springs -33P1			DI	Cl, EC	SO_4, TDS % Na, F, B	85 (β,γ)	Na HCO_3-SO_4	2-22-59	flow	Bathing
Chicago Valley 22N/7E-13L1		I	D	B	F		Na-Mg HCO_3	12- 4-56	25.0 ft	Unknown
Malipi Spring -30E1			DI	% Na	F, B	5.8 ± 3.3	Na HCO_3-SO_4	5- 9-61	flow	Irrigation Domestic
Death Valley Junction 25N/5E-14M1			DI		B, % Na, F	10.2 ± 1.6	Na HCO_3			Domestic
Hog Ranch 6E-18D1		I	D	% Na	F	1.8 ± 0.7	Na HCO_3	7-27-61	5.1 ft	Abandoned
Scranton 27N/4E-25E1		I	D	% Na	F	22.4 ± 2.7	Na HCO_3-SO_4	7-27-61	21.0 ft	Abandoned
-26B1	I		D		F	4.9 ± 1.1	Na HCO_3	7-27-61	23.8 ft	Unknown

D - Domestic
I - Irrigation

TABLE 20

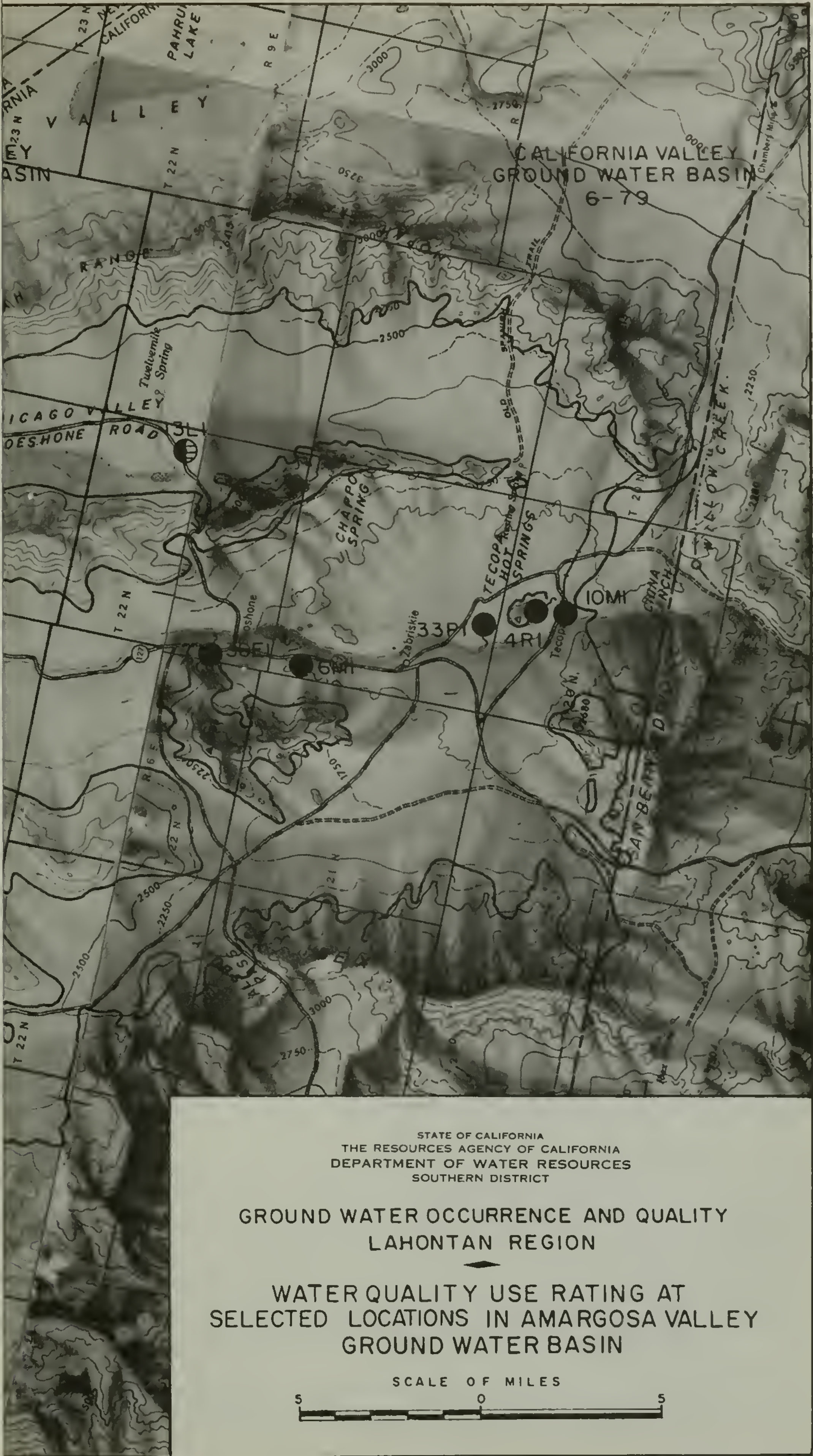
REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

AMARGOSA VALLEY GROUND WATER BASIN (6-20)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Scranton 27N/4E-27B1	I		D		F	11.7 ± 2.1	Na HCO_3			Domestic Irrigation

D - Domestic
I - Irrigation

FIGURE 12



STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN AMARGOSA VALLEY
GROUND WATER BASIN

SCALE OF MILES
5 0 5

LEGEND

GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)

SYMBOLS

○	WELL
	SPRING
	STREAM

WATER QUALITY USE RATING

DOMESTIC		IRRIGATION
SUITABLE		SUITABLE
MARGINAL		MARGINAL
INFERIOR	●	INFERIOR

Valjean Valley Ground Water Basin (6-21)

The Valjean Valley Ground Water Basin shown on Figure 13, is an irregularly shaped area of about 293 square miles located in the north central part of San Bernardino County within the Amargosa River Drainage Basin (No. 17).

It is bounded on the north by the Kingston Range and Dumont Hills, on the east by the Shadow Mountains, on the south by the Silurian Hills and an alluvial high, and on the west by the Avawatz Mountains.

Kingston peak rises to an elevation of 7,328 feet; other surrounding mountains range from 2,500 to 5,000 feet in elevation. The basin floor generally slopes to the west from an elevation of about 3,000 feet near its eastern edge to an elevation of about 500 feet near Salt Spring. Silurian Lake, in the southern part of the basin, covers an area of about 2.1 square miles.

Geology

To the north, the Dumont Hills consist of Tertiary and/or Quaternary sediments and the Kingston Range consists of pre-Tertiary granitic rocks. The Shadow Mountains to the east consist of pre-Tertiary metamorphic and granitic rocks and Tertiary sediments. Precambrian and Paleozoic sediments and metasediments and pre-Tertiary metamorphic rocks occur in the Silurian Hills to the south. An alluvial high also occurs here which extends from these hills to the Avawatz Mountains. The Avawatz Mountains and adjoining hills to the west consist of rocks similar to those found in the Silurian Hills.

Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a

Valjean Valley Ground Water Basin (6-21)

The Valjean Valley Ground Water Basin shown on Figure 13, is an irregularly shaped area of about 293 square miles located in the north central part of San Bernardino County within the Amargosa River Drainage Basin (No. 17).

It is bounded on the north by the Kingston Range and Dumont Hills, on the east by the Shadow Mountains, on the south by the Silurian Hills and an alluvial high, and on the west by the Avawatz Mountains.

Kingston peak rises to an elevation of 7,328 feet; other surrounding mountains range from 2,500 to 5,000 feet in elevation. The basin floor generally slopes to the west from an elevation of about 3,000 feet near its eastern edge to an elevation of about 500 feet near Salt Spring. Silurian Lake, in the southern part of the basin, covers an area of about 2.1 square miles.

Geology

To the north, the Dumont Hills consist of Tertiary and/or Quaternary sediments and the Kingston Range consists of pre-Tertiary granitic rocks. The Shadow Mountains to the east consist of pre-Tertiary metamorphic and granitic rocks and Tertiary sediments. Precambrian and Paleozoic sediments and metasediments and pre-Tertiary metamorphic rocks occur in the Silurian Hills to the south. An alluvial high also occurs here which extends from these hills to the Avawatz Mountains. The Avawatz Mountains and adjoining hills to the west consist of rocks similar to those found in the Silurian Hills.

Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 425 feet. Quaternary dune sand and lake deposits occur along the northwest and west edges of the basin respectively. Silurian Lake is a dry type of playa.

Water Supply

Sources of ground water replenishment to the basin are deep penetration of precipitation and percolation of streamflow originating in the watershed. The annual rainfall for the basin is estimated to be about three inches. Rainfall on the surrounding mountains occasionally supplies runoff to the basin. Kingston Wash, which extends in a westerly direction across the middle of the basin to the Amargosa River, is considered to have a high capacity for recharge and is probably the major recharge area. Surface drainage into the basin also may occur from Riggs basin by way of Salt Creek.

Subsurface inflow probably occurs from the Shadow Valley and Riggs Valley Ground Water Basins. Ground water supplies may be derived from the Recent and underlying older alluvial deposits. Ground water moves in a westerly direction into Death Valley basin; the ground water outflow from the basin is considered to feed Salt Spring.

Development and Utilization. Prospecting and mining in the surrounding mountains have been the major development in the basin. A well drilled to a depth of 425 feet near the townsite of Valjean encountered no water. The tracks of the Tonapah and Tidewater Railroad, which ran northward through the center of the basin were built about the turn of the century but have since been dismantled. The present water supply is derived only from the few springs in the basin.

Water Quality. Salt Spring (18N/7E-30D1) is the principal source of water in the basin. This spring has been known since Captain John C. Fremont camped nearby on April 28, 1844. The character of the spring water is sodium chloride and it is inferior for both domestic and irrigation uses as shown on Table 21. Since 1918 the total dissolved solids content has ranged from 5,385 to 8,540 ppm.

TABLE 21

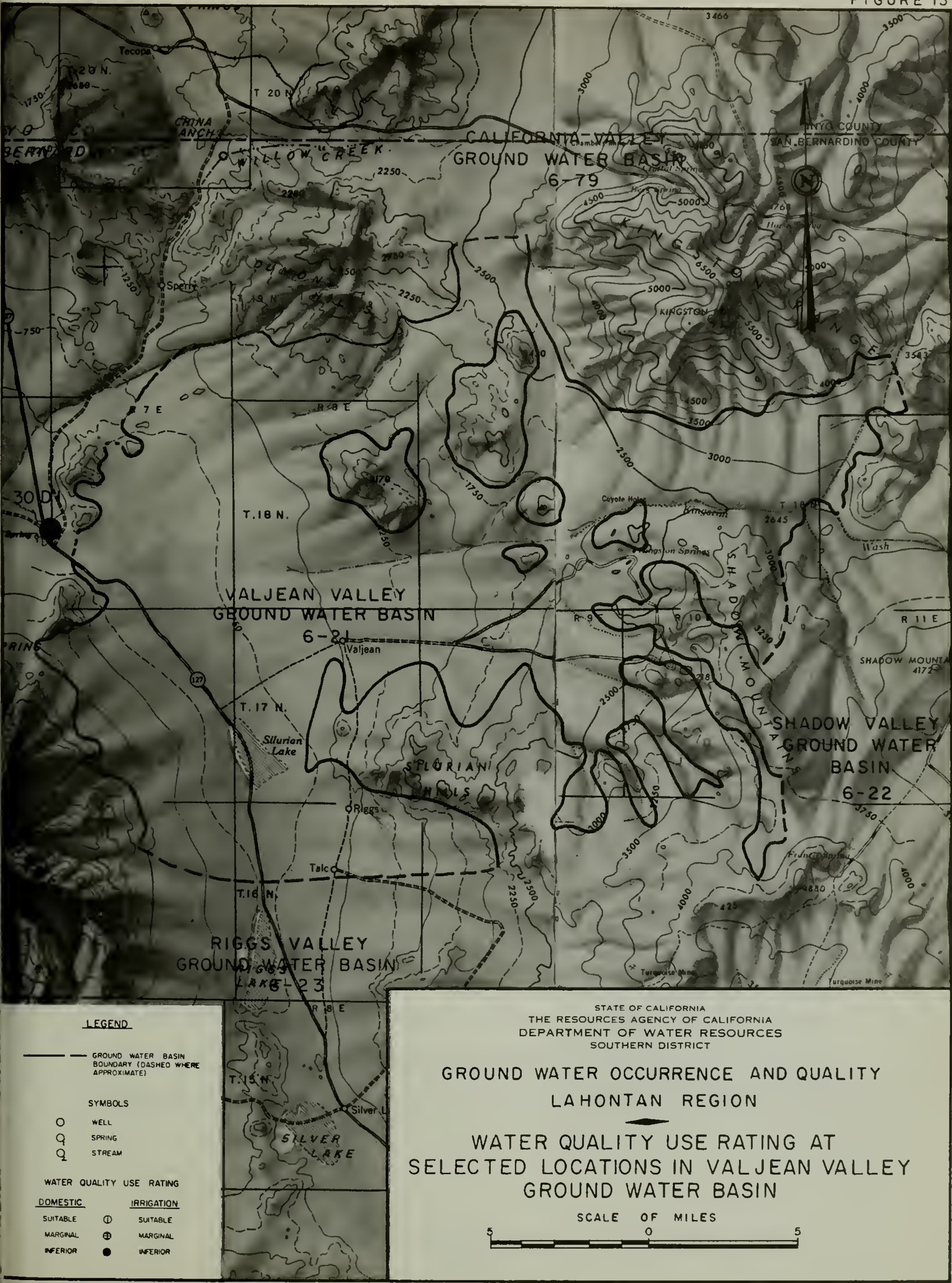
REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN

VALJEAN VALLEY GROUND WATER BASIN (6-21)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
Salt Spring 18N/7E-30D1			DI	EC, SO_4, Cl, F, B, TDS, % Na		8.7 ± 1.3 7.9 ± 0.9	Na Cl	1-14-18 4-21-54 5- 9-61	flow flow dry	Unknown

D - Domestic
I - Irrigation

FIGURE 13


Tecopa
T 20 N.
China Ranch
Willow Creek
CALIFORNIA VALLEY GROUND WATER BASIN 6-79
INYO COUNTY
SAN BERNARDINO COUNTY
Kingston Range
Kingston
Dumont Hills
Sperry
R 7 E
R 8 E
T. 18 N.
Coyote Holes
Kingston Springs
Kingston Wash
Shadow Mountains
VALJEAN VALLEY GROUND WATER BASIN 6-21
Valjean
R 9
R 10
R 11 E
Shadow Mountain 4172
T. 17 N.
Silurian Lake
Silurian Hills
Riggs
Talc
SHADOW VALLEY GROUND WATER BASIN 6-22
T. 16 N.
RIGGS VALLEY GROUND WATER BASIN 6-23
Turquoise Mine
T. 15 N.
Silver Lake
127
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
SUITABLE
MARGINAL
MARGINAL
INFERIOR
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT SELECTED LOCATIONS IN VALJEAN VALLEY GROUND WATER BASIN
SCALE OF MILES
5
0
5

Shadow Valley Ground Water Basin (6-22)

Shadow Valley Ground Water Basin, shown on Figure 14, is an irregularly shaped northwesterly trending area of about 271 square miles, located in the northeastern part of San Bernardino County, within the Amargosa River Drainage Basin (No. 17).

The basin is bounded on the north by the Mesquite Mountains, on the east by the Ivanpah and Clark Mountains, by Teutonia Peak on the south, and by the Shadow Mountains on the west.

The Kingston and Clark Mountains reach an elevation of 7,323 and 7,929 feet, respectively, and Teutonia Peak attains a maximum elevation of 5,710 feet. The valley floor slopes northwesterly from an elevation of about 5,000 feet near Teutonia Peak to 3,000 feet near Kingston Wash.

Geology

The Mesquite Mountains to the north consist of Precambrian and Paleozoic sediments and metasediments and pre-Tertiary granitic rocks. The Ivanpah and Clark Mountains to the east consist of pre-Tertiary granitic rocks, Tertiary and/or Quaternary sediments and rock similar to those found in the Mesquite Mountains. Teutonia Peak is a prominent feature of the pre-Tertiary granitic rocks which occur to the south and southwest. Cinder cones occur in the Quaternary volcanic rocks to the south and southwest. To the west, the Shadow Mountains consist of Precambrian and Paleozoic sediments and metasediments, pre-Tertiary metamorphic rocks, Tertiary sediments, and Tertiary and/or Quaternary sediments.

Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 400 feet. Quaternary lake deposits occur in the south central part of the basin near the old town site of Valley Wells. The Mesquite thrust is a major fault zone in the Clark Mountains. A similar type fault also occurs in the Shadow Mountains.

Water Supply

The principal source of ground water replenishment in the basin is percolation of streamflow resulting from precipitation on the highland areas of the watershed. The annual rainfall on the valley floor is estimated to be from 5 to 7 inches, while that on the surrounding mountains may be greater than 10 inches. There are many gullies incised in the valley floor which drain to the north toward Kingston Wash. This wash in turn drains westward out of the basin to Valjean Valley. The alluvial fans of the Ivanpah Mountains are the major recharge areas for the basin and their capacity for absorbing and transmitting water is rated moderate to high.

Ground water within the basin which is found in the Recent and underlying older alluvial deposits moves in a northerly direction, probably toward Kingston Wash. The hydraulic gradient from well 15N/12E-16H1 northward to well 16N/12E-33B1 is about 40 feet per mile. Although there are no wells in the northern part of the basin, it is possible that there is subsurface outflow from the basin into Valjean Valley. Since records were first maintained in 1953, ground water levels have remained constant.

Development and Utilization. Several mines on the western slopes of the Clark and Ivanpah Mountains operated sporadically in the early 1900's. Most of the ore obtained from these mines which included copper, silver, gold, and tungsten was of low grade. Some of the copper ore from the Copper World Mine was processed at a smelter in Valley Wells and in 1918 there were about 50 men working this operation. The capacity of the smelter was about 150 tons per day. When cattle ranching was prevalent, it is estimated that about 150 people lived in the valley.

Presently, there are about 10 wells in the valley, all of which are located close to U.S. Highway 91 (466). A number of these wells were drilled for water to be used in the widening of this highway.

Ground water is used mainly for stock and domestic purposes and it is estimated that the annual ground water extraction in the valley is about 15 acre-feet per year. There are presently about 50 people living in the valley.

Water Quality. The quality of the ground water, as shown on Table 22, has remained marginal to inferior for domestic use for those wells sampled since the period of record beginning in 1953. However, the character of the ground water is variable. The total dissolved solids content of ground water from 10 wells and springs ranges from 344 to 1,060 ppm and averages about 592 ppm. Water from well 16N/12E-26N1 is inferior for domestic use because of its high sulfate content (586 ppm). The percent sodium ranges from 21 to 79 percent, while the fluoride content averages 1.4 ppm.

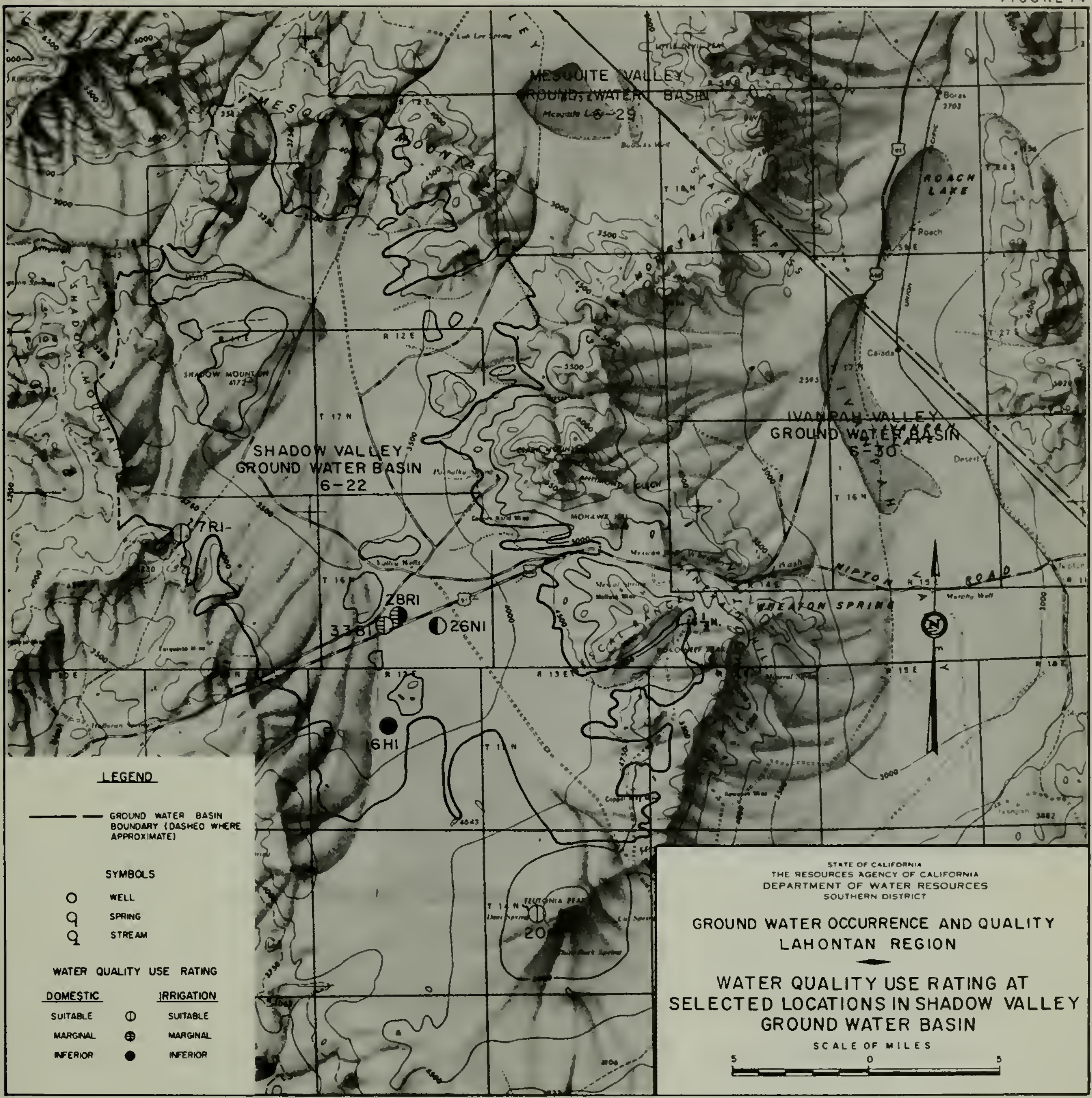
TABLE 22

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN SHADOW VALLEY GROUND WATER BASIN (6-22)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Deer Spring 14N/13E-20G1	DI						Ca HCO3			Unknown
15N/12E-16H1			DI		% Na, F		Na HCO_3	4-16-53	166 ft	Domestic Stock
16N/12E-26N1	I		D	TDS	SO_4	6.39 ± 1.87	Ca-Mg SO_4	4-16-53 5-13-57 5-11-61	46.5ft 46.3ft 48.0ft	Stock
16N/12E-28R1		D	I	F	% Na		Na HCO_3-SO_4			Domestic Industrial
16N/12E-33B1	I	D		F		2.3 ± 1.0 6.2 ± 0.9 2.58 ± 1.82	Na-Ca SO_4	9-13-53 11-17-56 5-15-59	80 ft 78.8ft 81 ft	Domestic
Francis Spring 16N/11E-7R1	DI						Na HCO_3	1917	7 ft	Unknown

D - Domestic
I - Irrigation

FIGURE 14


MESQUITE VALLEY
GROUND WATER BASIN
6-29
ROACH LAKE
IVANPAH VALLEY
GROUND WATER BASIN
6-30
SHADOW VALLEY
GROUND WATER BASIN
6-22
SHADOW MOUNTAINS
NIPTON ROAD
WHEATON SPRING
MOHAWK HILL
17R1
28R1
33B1
26N1
16H1
20
R 12 E
R 13 E
R 15 E
T 17 N
T 16 N
T 15 N
T 14 N
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
SUITABLE
MARGINAL
MARGINAL
INFERIOR
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN SHADOW VALLEY
GROUND WATER BASIN
SCALE OF MILES
5
0
5

Riggs Valley Ground Water Basin (6-23)

Riggs Valley Ground Water Basin, shown on Figure 15, is an irregularly shaped area of about 99 square miles, located in the north central portion of San Bernardino County, within the Amargosa River Drainage Basin (No. 17).

This basin is bounded on the north by an alluvial high, by a series of low hills on the east and southeast, by the Soda Mountains on the south, and by the Avawatz Mountains on the west.

The Avawatz Mountains rise to an elevation of 6,200 feet, while other bordering mountains range from 2,500 to 3,500 feet in elevation. The basin floor slopes from 2,500 feet on the upper edges of the alluvial slopes toward Riggs Lake, which stands at an elevation of 750 feet. This dry lake covers an area of about 2.2 square miles.

Geology

An extensive alluvial high occurs to the north, forming the boundary between the Riggs and Valjean Ground Water Basins. The hills to the east and southeast consist of pre-Tertiary granitic and metamorphic rocks. The Soda Mountains to the south consist of Precambrian and Paleozoic sediments and metasediments, Triassic metasediments and metavolcanic rocks, and pre-Tertiary granitic rocks. Along the western edge of the basin, pre-Tertiary metamorphic rocks and Tertiary sediments occur in the Avawatz Mountains; Triassic metasediments and metavolcanic rocks occur in their southerly extension.

The Quaternary alluvium, which comprises the upper portion of the valley fill, is exposed over most of the basin floor. Riggs Lake is a dry type of playa and has a hard, smooth surface.

Water Supply

The principal source of ground water replenishment to Riggs Valley Ground Water Basin is percolation of streamflow originating in the watershed. The annual rainfall for the basin is probably less than three inches. Surface flows consist of runoff from the surrounding mountains. On rare occasions Silver Lake has overflowed into the basin from the adjoining Silver Lake Ground Water Basin when the Mojave River has carried flood waters. Riggs Lake drains northward into Salt Creek when runoff fills the lake. However, Salt Creek, which drains in a northwesterly direction into Silurian Lake and thence to the Amargosa River, is dry most of the year.

Alluvial fans on the Avawatz and Soda Mountains are the basin's main recharge areas and their capacity is rated as moderate to high. Ground water which is found in Recent and underlying older alluvium probably moves northward into the adjoining Valjean Ground Water Basin. Subsurface inflow occurs from Silver Lake Valley Ground Water Basin to the east. There are no known wells in the basin.

Development and Utilization. Sporadic mining activities in the surrounding mountains have been the only known development in the area. The Tonopah and Tidewater Railroad at one time passed through the northwestern part of the basin; today only the railroad bed remains.

Water Quality. The quality of the ground water in the basin is affected by the subsurface inflow of ground water from Silver Lake basin to the east. The quality of this inflow is probably inferior for both irrigation and domestic uses as indicated by water from well

15N/8E-15Q1. As shown on Table 22, high concentrations of fluoride (4.0 ppm), chloride (620 ppm), and percent sodium (88 percent) are the causes of this inferior quality. The total dissolved solids content for water from this well was 1,740 ppm, which is in the marginal range. The sodium chloride character of the water is the same as that of Salt Spring (18N/7E-30D1).

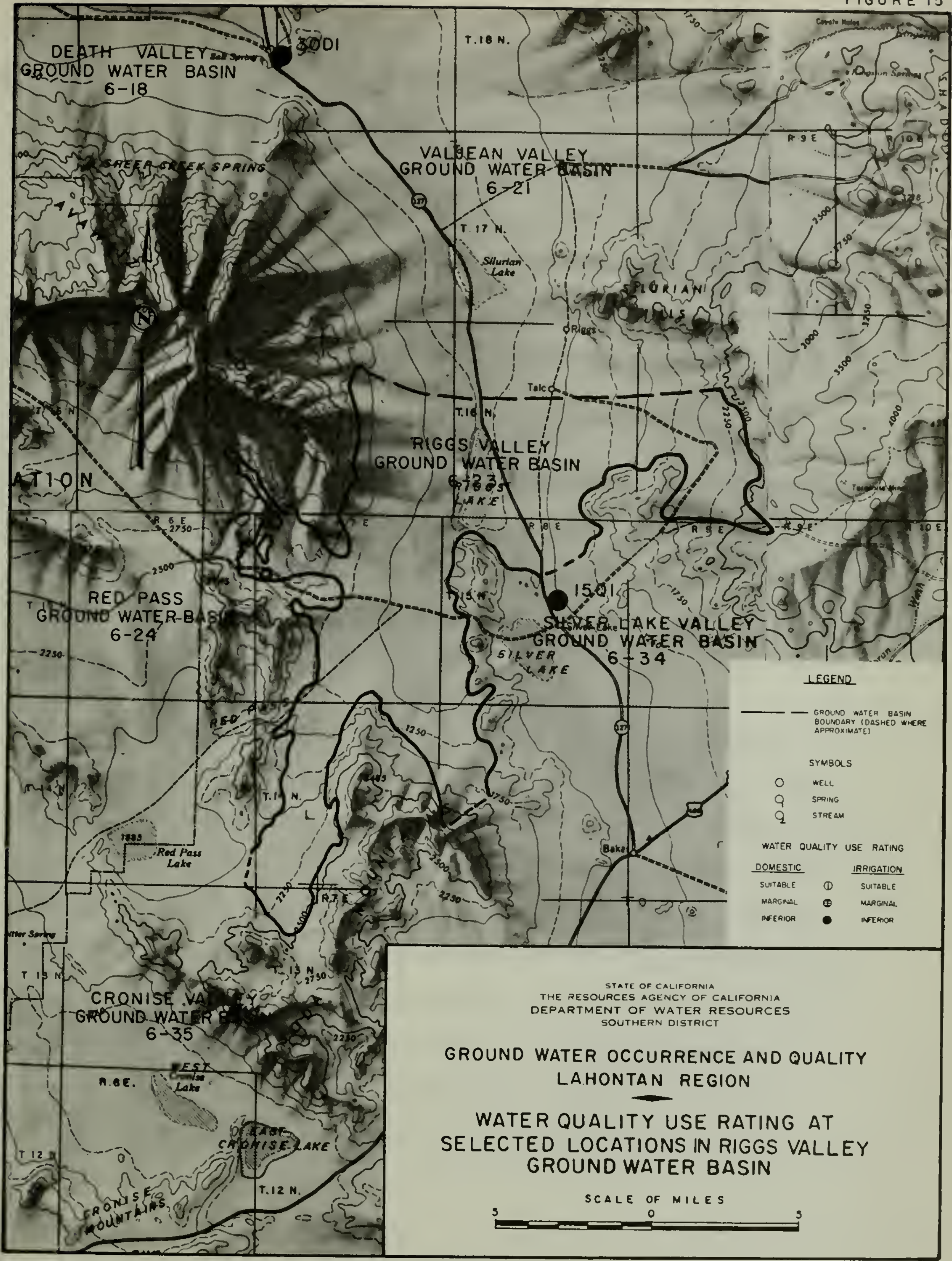
TABLE 23

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
RIGGS VALLEY GROUND WATER BASIN (6-23)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
15N/8E-15Q1			DI	EC, B, TDS	Cl, F, % Na		Na Cl	2-19-54	138	Domestic
Salt Spring 18N/7E-30D1			DI		EC, SO_4, Cl F, B, TDS, % Na	8.7 ± 1.3 7.9 ± 0.9	Na Cl	1-14-18 4-21-54 5- 9-61	flow flow dry	Unused

D - Domestic
I - Irrigation

FIGURE 15



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DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN RIGGS VALLEY GROUND WATER BASIN

Red Pass Valley Ground Water Basin (6-24)

Red Pass Valley Ground Water Basin, shown on Figure 16, is an irregularly shaped 155 square mile area located in the north central part of San Bernardino County, within the Amargosa Drainage Basin (No. 17).

The basin is bordered by the Granite Mountains on the north, the Avawatz Mountains on the northeast and east, the Soda Mountains and Tiefort Mountains on the south, and by a buried bedrock ridge and low hills on the west.

The Avawatz Mountains reach an altitude of about 5,300 feet; other surrounding mountains range from 2,300 to 3,900 feet in elevation. The basin slopes southward from approximately 4,000 feet at its northern extremity to an elevation of 1,858 feet at Red Pass Lake. This dry lake covers an area of about 1.2 square miles.

Geology

The Granite Mountains to the north consist predominately of pre-Tertiary granitic rocks with some Tertiary and/or Quaternary sediments. The Avawatz Mountains to the north and east include pre-Tertiary granitic rocks, Triassic metasediments and metavolcanic rocks, and Tertiary sediments. Pre-Tertiary granitic and metamorphic rocks and Tertiary and/or Quaternary sediments are exposed to the south in the Tiefort Mountains. Similar type rocks, Triassic metasediments and metavolcanic rocks, and Tertiary volcanic rocks occur in the Soda Mountains to the south. A buried bedrock ridge and hills consisting of pre-Tertiary granitic, and Quaternary volcanic rocks occur to the west.

Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 500 feet. Red Pass Dry Lake is a dry type of playa.

Water Supply

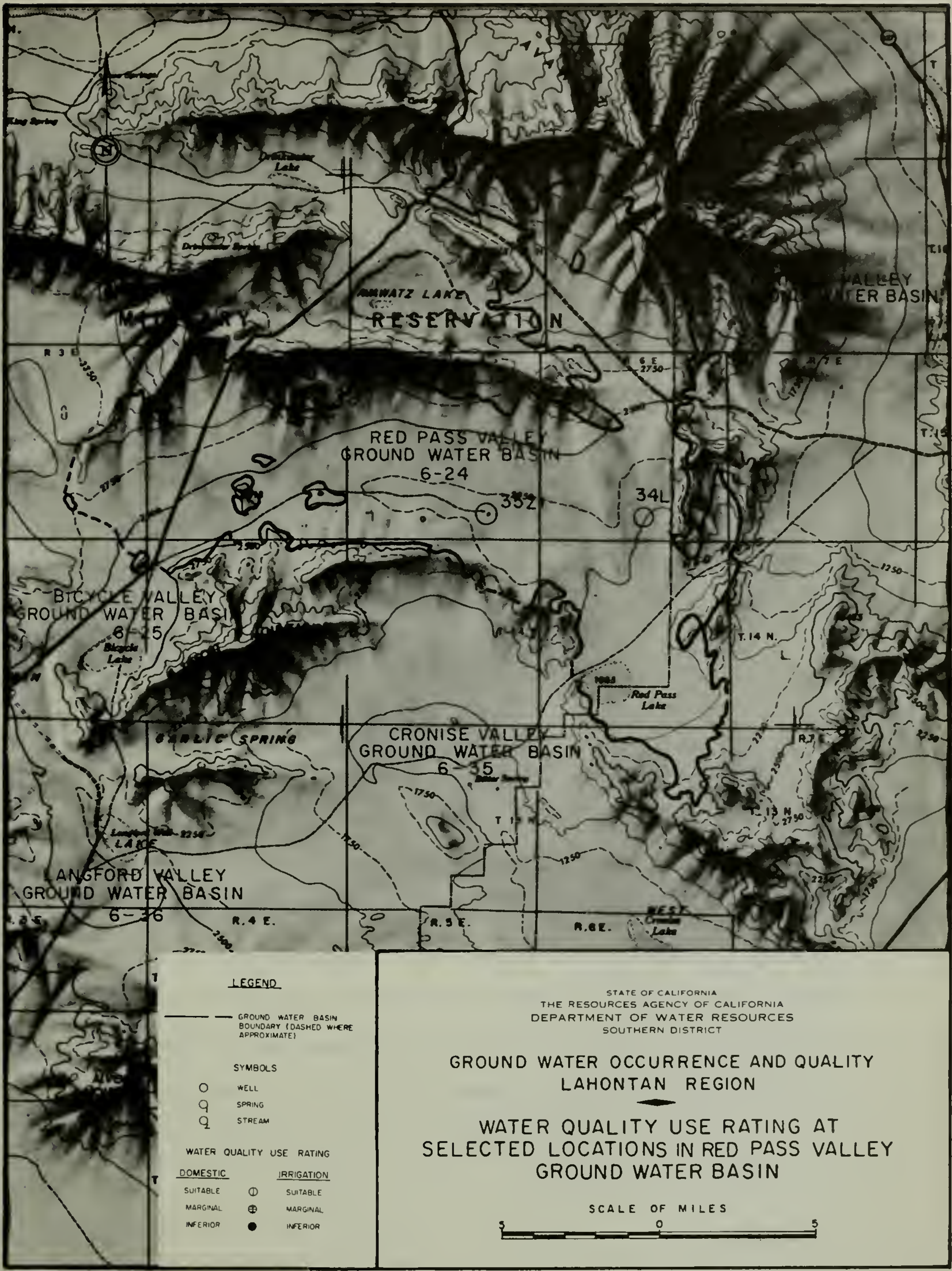
The principal source of ground water replenishment to Red Pass Valley Ground Water Basin is percolation of streamflow originating in the watershed. The annual rainfall is probably less than four inches. Runoff from the surrounding mountains is the basin's only source of surface water. The principal recharge areas are the alluvial fans of the Avawatz and Soda Mountains which have a moderate recharge capacity.

Ground water is stored in Recent and underlying older alluvial deposits. Subsurface outflow may occur from the southern portion of the basin into Cronise basin. There is only one known drilled well (15N/6E-34L1) in the basin at present and in May 1944, depth to water in this well was 368 feet. This well was drilled in connection with water supplies for the Camp Irwin Military Reservation.

Development and Utilization. The great depth to water in the basin has discouraged any homesteading or irrigation. Presently, Camp Irwin personnel are the only people known to use this area.

The only wells known to exist are the test well previously mentioned and a dug well (15N/5E-35Z1) which was reported to be dry to a depth of 65 feet. There is no known extraction of the ground water from the basin at present.

Water Quality. There has been no known chemical or radioactivity analysis made on the ground water in the basin.


RESERVATION
RED PASS VALLEY
GROUND WATER BASIN
6-24
352
34L
BICYCLE VALLEY
GROUND WATER BASIN
6-25
Bicycle Lake
Red Pass Lake
CRONISE VALLEY
GROUND WATER BASIN
6-35
GARLIC SPRING
LANGFORD VALLEY
GROUND WATER BASIN
6-36
R.4 E.
R.5 E.
R.6E.
WEST Cronise Lake
T.14 N.
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
SUITABLE
MARGINAL
MARGINAL
INFERIOR
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN RED PASS VALLEY
GROUND WATER BASIN
SCALE OF MILES
5
0
5

Bicycle Valley Ground Water Basin (6-25)

Bicycle Valley Ground Water Basin, shown on Figure 17, is an irregularly shaped, northwesterly trending area of about 122 square miles located in the northern part of San Bernardino County within the Amargosa River Drainage Basin (No. 17).

Bicycle basin is bounded on the north and northeast by the Granite Mountains, on the east by a buried bedrock ridge, on the southeast by the Tiefort Mountains, and by a series of unnamed mountains on the southwest and northwest.

The Granite Mountains reach an elevation of 5,299 feet, and the other mountainous areas average about 4,500 feet in elevation. The valley floor ranges in elevation from about 3,300 feet along the northern margins of the basin to 2,351 feet at Bicycle Lake to the south. This dry lake covers an area of 2.1 square miles.

Geology

The Granite Mountains to the north and northeast consist of pre-Tertiary granitic rocks. A buried bedrock ridge with hills of pre-Tertiary granitic and Quaternary volcanic rocks occur to the east. Similar type rocks and pre-Tertiary metamorphic rocks occur to the southeast in the Tiefort Mountains. The mountains to the southwest consist predominantly of Tertiary volcanic rocks with some pre-Tertiary granitic and metamorphic rocks, Quaternary volcanic rocks, and Tertiary and/or Quaternary sediments. Pre-Tertiary granitic rocks and Tertiary and Quaternary volcanic rocks occur in the hills to the northwest.

Quaternary alluvium is exposed over a portion of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 440 feet. Bicycle, McLean, and Nelson Lakes are dry types of playas.

Water Supply

The sources of ground water replenishment to the basin are deep penetration of precipitation and percolation of streamflow originating in the watershed. The annual rainfall is probably less than two inches and surface inflow to the basin is limited to the occasional runoff from the surrounding mountains. The alluvial fans from the Granite and Tiefort Mountains are the main recharge areas and are rated as moderate to high.

Ground water, which is found in the Recent and underlying older alluvium, probably moves in a southerly direction toward Bicycle Lake. This internally drained basin has no known subsurface inflow or outflow. The depth to water in the only well in the basin (14N/3W-13K1) was 171 feet in February 1955.

Development and Utilization. The first known activity in the basin began in 1940 when Camp Irwin, a military reservation, was established. The main post of Camp Irwin is located in the Langford basin, however, military exercises are held throughout the area of the Bicycle Valley Ground Water Basin. Bicycle Lake is utilized as an emergency landing field. Well 14N/3W-13K1 was drilled for test purposes in connection with a study to develop a water source closer to Camp Irwin. The well is not used at present and has been capped.

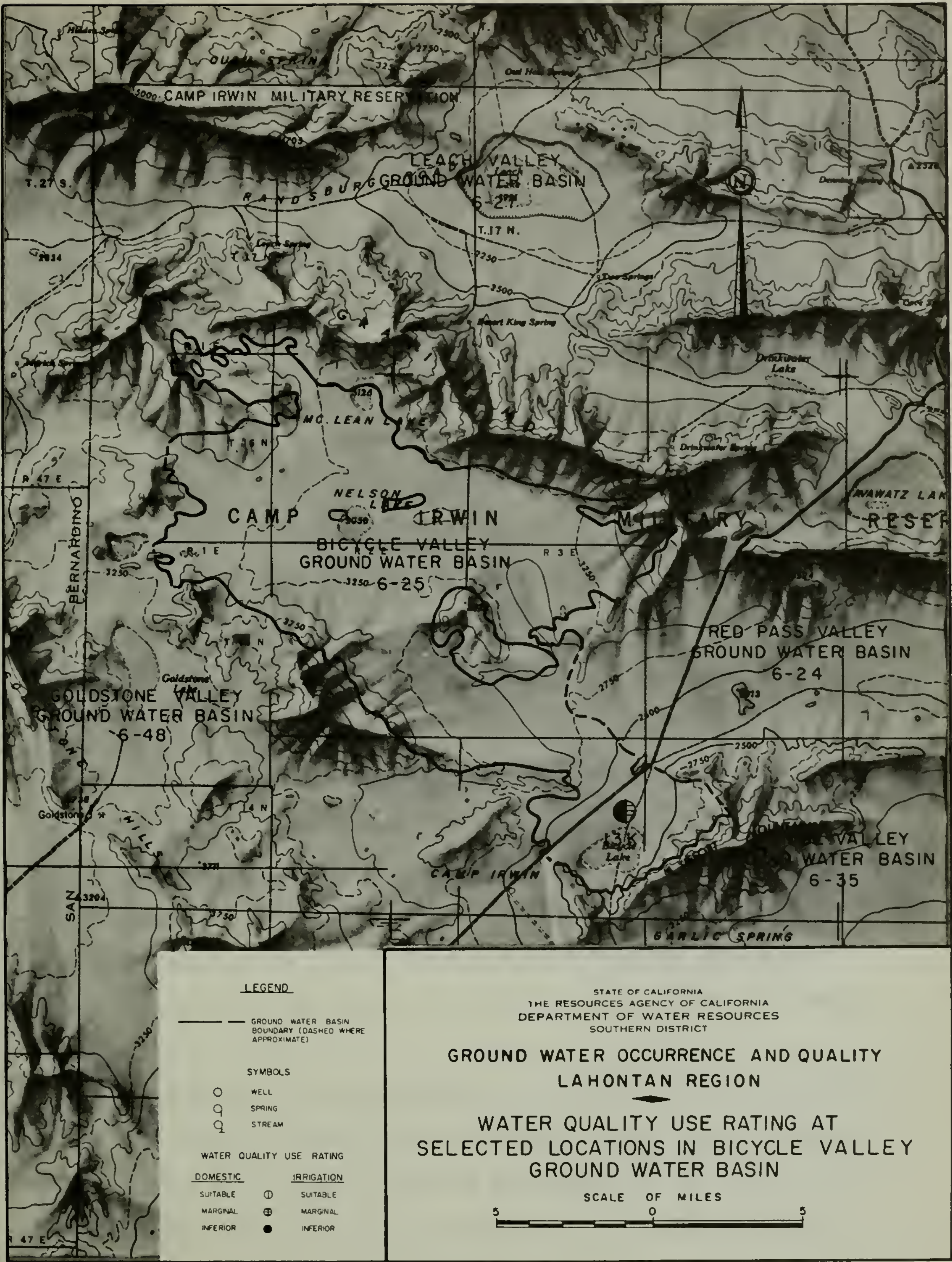
Water Quality. The results from a chemical analysis of water from well 14N/3W-13K1 indicate it to be inferior for domestic use because of its fluoride content of 1.6 ppm. A percent sodium of 74 classifies this water as marginal for irrigation purposes, as shown on Table 24. The general character of the water is sodium bicarbonate and it has a total dissolved solids content of 608 ppm.

TABLE 24

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
BICYCLE VALLEY GROUND WATER BASIN (6-25)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
14N/3W-13K1		I	D	% Na	F		Na HCO_3	2-55	171 ft	Test

D - Domestic
I - Irrigation



LEGEND

GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)

SYMBOLS

○ WELL

SPRING

STREAM

WATER QUALITY USE RATING

DOMESTIC		IRRIGATION
SUITABLE	⦶	SUITABLE
MARGINAL	⊕	MARGINAL
INFERIOR	●	INFERIOR

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN BICYCLE VALLEY GROUND WATER BASIN

SCALE OF MILES

5 0 5

Leach Valley Ground Water Basin (6-27)

Leach Valley Ground Water Basin, shown on Figure 18, is an irregularly shaped east-west trending area of about 68 square miles located in the north central part of San Bernardino County, within the Amargosa River Drainage Basin (No. 17).

The Owlshead, Quail, and Avawatz mountains encircle the basin on the north as do the Granite Mountains on the south. An alluvial high bounds the basin on the west.

The Granite Mountains rise to an elevation of 4,474 feet, the Quail Mountains attain a maximum elevation of 5,100 feet, while the remaining mountainous areas rise to a maximum of 3,800 feet in elevation. The basin floor slopes centripetally toward Leach Lake; the floor ranges in elevation from 2,500 at its outer limits to 1,921 feet at the dry lake which covers an area of 2.05 square miles.

Geology

The Quail, Owlshead, and Avawatz Mountains to the north include pre-Tertiary granitic and metamorphic rocks, Tertiary volcanic rocks, Tertiary sediments, and Tertiary and/or Quaternary sediments. The Granite Mountains to the south consist of pre-Tertiary granitic rocks while the Avawatz Mountains also include Triassic metasediments and metavolcanic rocks. An alluvial high occurs to the west between the Quail and Granite Mountains.

Quaternary alluvium, which is exposed on most of the basin floor, comprises the upper portion of the valley fill. The easterly trending Garlock fault zone extends through the mountains along the northern part of the basin. One of the faults from this zone divides Leach Lake, a compound type of playa, into two parts. The northern part of the playa is moist; the southern part, dry.

Water Supply

The principal source of ground water replenishment to Leach Lake Valley Ground Water Basin is percolation of streamflow originating in the watershed. The annual rainfall for the basin is probably less than four inches. During cloud bursts, the numerous washes which drain the surrounding mountains may convey runoff to the basin. Alluvial fans from the Quail and Granite Mountains are the basin's major recharge areas and their capacity is rated as moderate. There are no drilled wells in the basin, but it is believed that the ground water which is probably stored in the Quaternary alluvium and underlying sediments moves toward Leach Lake. The depth to ground water on the north moist side of the dry lake is probably less than 10 feet. The basin is believed to have no subsurface inflow or outflow.

The only water supply is obtained from three springs located in the ravines on the southern side of the basin. These developed springs have been observed to be either flowing or to be within a foot of the ground surface since 1917.

Development and Utilization. Leach Spring (17N/1E-24D1) was a well-known watering place in the Mojave Desert and was used by the "Twenty Mule Teams" traveling the old Randsburg Road, which passes about two miles north of the spring. The springs were probably developed by people who traveled through this basin. Some prospectors have been in the area at various times, but there has never been homesteading or any other development in the basin. No one is known to be presently living in the basin.

Water Quality. The only available analyses of water from the basin are from Leach Spring (17N/1E-24D1), Desert King Spring (17N/2E-36B1), and Two Springs (17N/3E-22J1). As shown on Table 25, these spring waters are marginal or inferior for domestic purposes due to the concentrations of fluoride of 2.0, 1.0, and 22.5 ppm, (the highest value found in the Lahontan Region) respectively. Two Springs water is also considered inferior for irrigation purposes because it has a sodium content of 96.5 percent. The total dissolved solids content ranges from 308 to 698 ppm and the character of these waters varies.

The quality of ground water in the basin, other than the springs, is unknown due to the lack of any wells. Ground water in the vicinity of the dry lake probably would be highly mineralized, but ground water of suitable quality might be encountered on the higher portions of the alluvial fans.

TABLE 25

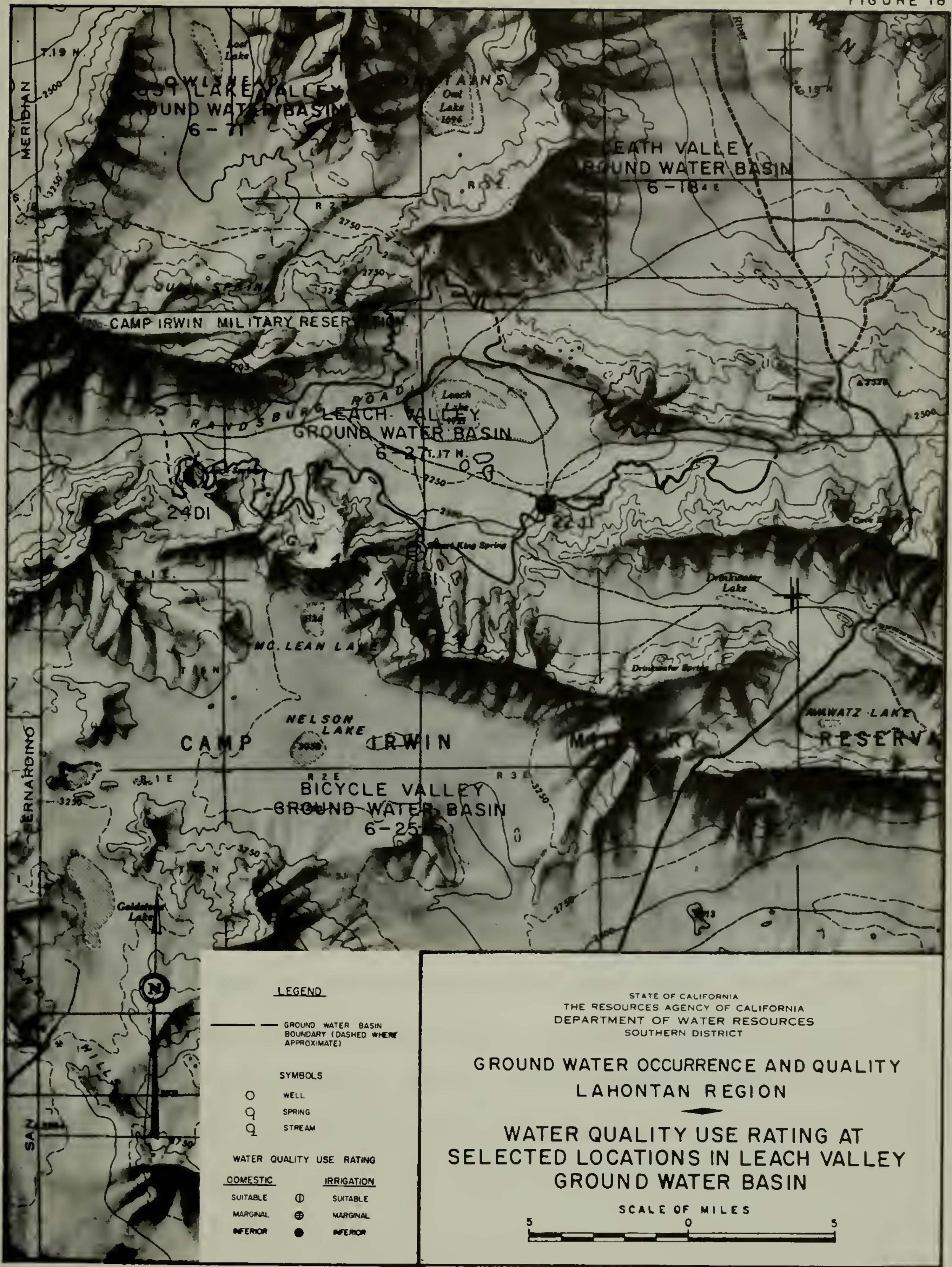
REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

LEACH VALLEY GROUND WATER BASIN (6-27)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Leach Spring 17N/1E-24D1	I		D		F		Ca-Na HCO_3-Cl	10-14-17	flow	Unknown
Desert King Spring 17N/2E-36B1	I	D		F			Na Cl-HCO_3	10-18-17	1 ft	Unknown
Two Springs 17N/3E-22J1			DI		F, % Na		Na SO_4-Cl	10-19-17 6-15-53	flow flow	Unknown

D - Domestic
I - Irrigation

FIGURE 18



STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN LEACH VALLEY GROUND WATER BASIN

Lost Lake Valley Ground Water Basin (6-71)

Lost Lake Valley Ground Water Basin, shown on Figure 19, is an irregularly shaped, generally northerly trending area of about 41 square miles located immediately south of the Inyo-San Bernardino County line in San Bernardino County, within the Amargosa River Drainage Basin (No. 17).

The basin is completely enclosed by the Owlshead Mountains, except on the south where it is bounded by the Quail Mountains. The Owlshead Mountains rise to an elevation of 4,400 feet and the Quail Mountains attain a maximum elevation of 5,100 feet. Elevations of the floor of the basin range from 2,335 feet at Lost Lake to 3,000 feet along the southwest portion of the basin.

Geology

The Owlshead Mountains consist predominantly of pre-Tertiary granitic, Tertiary volcanic, and Tertiary-Quaternary volcanic rocks. Tertiary and/or Quaternary sediments occur to the southeast and in the drainage divide to the north. Quaternary alluvium, which is exposed over most of the basin floor, comprises the upper portion of the valley fill. Lost Lake is a dry type of playa, covering an area of about 4.4 square miles.

Water Supply

The principal source of ground water replenishment to Lost Lake Valley Ground Water Basin is percolation of streamflow originating in the watershed. The basin annually receives about five inches of rain and has a relatively small drainage area. Runoff flows to the east side of the larger part of the basin, thence to Lost Lake.

The fans fringing the basin are considered to be the ground water recharge areas and are believed to be capable of a moderate recharge rate. Ground water is stored in Recent and underlying older alluvial deposits. Depth to ground water is unknown, however, the hydraulic gradient would probably be nearly flat and slope down toward Lost Lake or to the northern end of the basin.

Development and Utilization. The basin has no known wells or other development except for a few small mines. Quail Spring, on the north slope of the Quail Mountains, is the only known source of water in the area and is utilized by prospectors for domestic purposes.

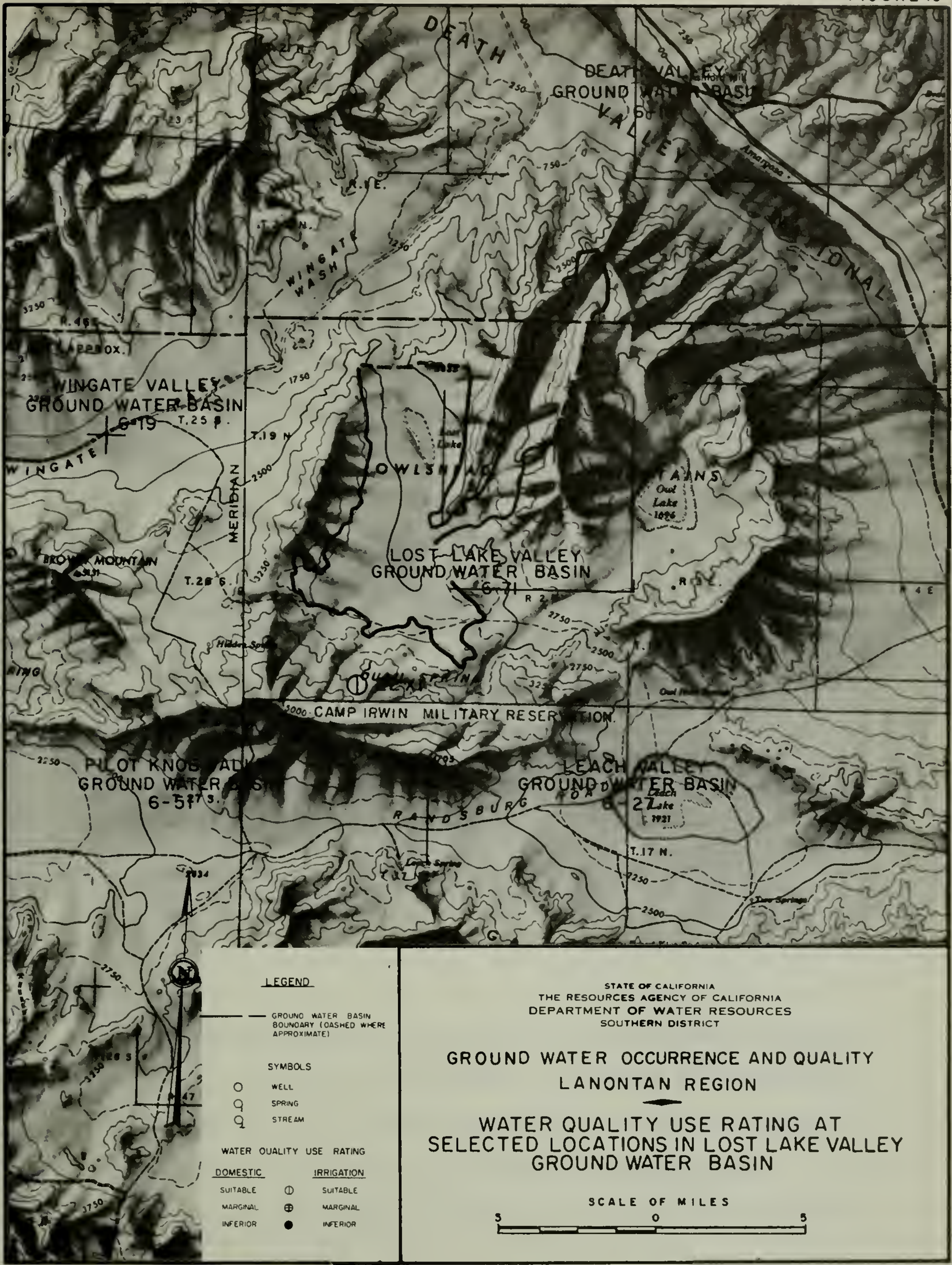
Water Quality. The water obtained from Quail Spring is considered to be suitable for all prevailing uses, as shown on Table 26. It has a total dissolved solids content of 356 ppm and is sodium bicarbonate-chloride in character.

TABLE 26

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
LOST LAKE VALLEY GROUND WATER BASIN (6-71)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
Quail Spring 18N/1E-22X1	DI						Na HCO_3-Cl	6-15-53	flow	Domestic

D - Domestic
I - Irrigation


DEATH VALLEY
DEATH VALLEY GROUND WATER BASIN 6-18
WINGATE WASH
WINGATE VALLEY GROUND WATER BASIN 6-19
OWLSHEAD
LOST LAKE VALLEY GROUND WATER BASIN 6-71
QUAIL SPRING
CAMP IRWIN MILITARY RESERVATION
PILOT KNOB VALLEY GROUND WATER BASIN 6-51
LEACH VALLEY GROUND WATER BASIN 6-27
RANDSBURG ROAD
MERIDIAN
BROWN MOUNTAIN
Leach Lake
Owl Lake
T.19 N.
T.17 N.
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
SUITABLE
MARGINAL
MARGINAL
INFERIOR
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LANONTAN REGION
WATER QUALITY USE RATING AT SELECTED LOCATIONS IN LOST LAKE VALLEY GROUND WATER BASIN
SCALE OF MILES
5
0
5

Denning Spring Valley Ground Water Basin (6-78)

The Denning Spring Valley Ground Water Basin, shown on Figure 20, is a small elongate, northwesterly trending area of about 12 square miles located in the north central part of San Bernardino County within the Amargosa River Drainage Basin (No. 17).

The Avawatz Mountains, which nearly encircle the basin, attain a maximum elevation of about 6,000 feet. The floor of the basin slopes in a northwesterly direction ranging in elevation from about 5,400 feet to 1,600 feet.

Geology

The basin is bordered by a complex of pre-Tertiary granitic and metamorphic rocks, Paleozoic sediments, Triassic metasedimentary and metavolcanic rocks, Tertiary sediments, and Tertiary volcanic rocks of the Avawatz Mountains. This fault-controlled basin occurs near the junction of the Garlock and Death Valley fault zones, which account for the lithologic and structural complexity of the basin. The unconsolidated sediments which are exposed over the basin floor comprise the upper portion of the valley fill.

Water Supply

The principal source of ground water replenishment to Denning Spring Valley is percolation of streamflow originating in the watershed. The annual rainfall for the valley is probably less than five inches and the only surface flow occurs as runoff from the surrounding mountains. Fans of the Avawatz Mountains are the major recharge areas for the valley and the capacity of these fans is rated as moderate. There is no subsurface inflow to the basin, but ground water which is found in Recent and underlying older alluvial deposits probably moves in a northwesterly direction into Death Valley basin.

The water level in the Denning Spring Well (17N/5E-5X1), the only known well within the basin, has been within four feet of the ground surface since 1917.

Development and Utilization. Denning Spring and Denning Spring Well, located in the northern part of the basin, have been used by prospectors. Another spring also in this area is Cave Spring (17N/5E-27X1) which is situated south of the basin but within its drainage area. There never has been any significant development in the basin and presently there is no ground water extraction.

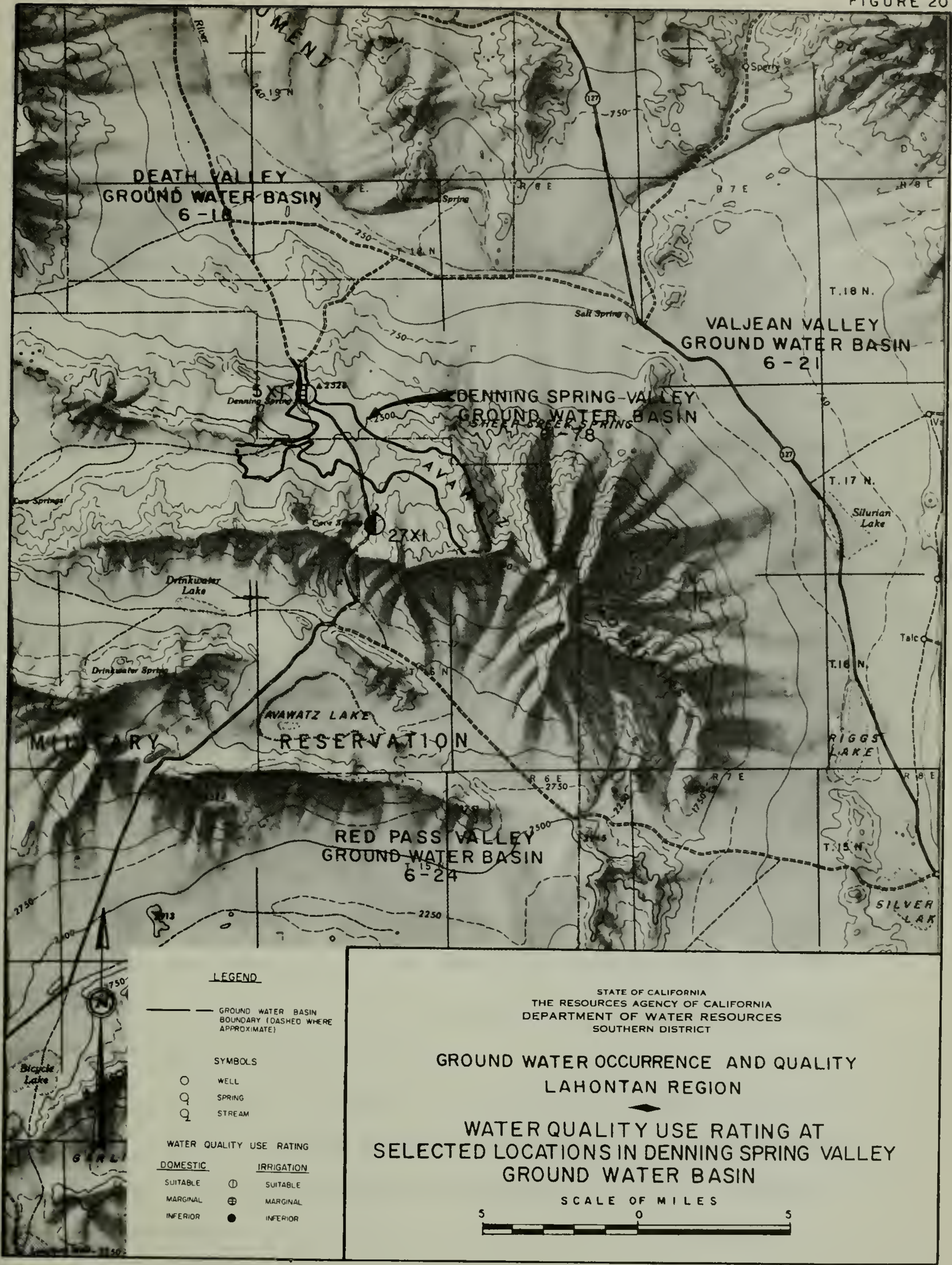
Water Quality. As shown on Table 27, the quality of the water from the Denning Spring Well and Cave Spring is rated as marginal and inferior, respectively, for domestic use. This rating is based on the fluoride content of the water: Cave Spring has a fluoride concentration of 2.5 ppm; water from the Denning Spring Well has a fluoride content of 1.2 ppm. The water at Cave Spring is calcium bicarbonate-sulfate in character; the water from the Denning Spring Well, calcium-sodium bicarbonate. Water from both sources have a total dissolved solids content of about 450 ppm.

TABLE 27

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
DENNING SPRING VALLEY GROUND WATER BASIN (6-78)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Denning Spring Well 17N/5E-5X1	I	D		F			Ca-Na HCO_3	9- 7-17 6-10-53	4 ft 3 ft	Unknown
Cave Spring 17N/5E-27X1	I		D		F		Ca HCO_3 - SO_4			Unknown

D - Domestic
I - Irrigation



LEGEND

GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)

SYMBOLS

WELL

SPRING

STREAM

WATER QUALITY USE RATING

DOMESTIC		IRRIGATION
SUITABLE		SUITABLE
MARGINAL		MARGINAL
INFERIOR		INFERIOR

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN DENNING SPRING VALLEY
GROUND WATER BASIN

SCALE OF MILES

5 0 5

California Valley Ground Water Basin (6-79)

California Valley Ground Water Basin, shown on Figure 21, is a roughly triangular shaped area of about 80 square miles located in the southeast portion of Inyo County, and partially extending into northeastern San Bernardino County, within the Amargosa River Drainage Basin (No. 17).

The basin is bordered on the northeast by a group of low mountains, by the Kingston Range and adjoining mountains on the southeast, by the Dumont Hills on the southwest, and by the Nopah Range on the west.

Kingston Peak, rising to an elevation of 7,328 feet, is the highest point within the drainage area of the valley. Elevations of the valley floor range from a low of 2,200 feet at the southwest corner to 3,000 feet in the northern end of the basin.

Geology

To the northeast, buried bedrock ridges occur between low mountains composed of Precambrian and Palezoic sediments and metasediments and Quaternary sediments. The Kingston Range and adjoining mountains to the southeast consist of pre-Tertiary granitic and metamorphic rocks, and Precambrian and Paleozoic sediments and metasediments. Precambrian and Paleozoic sediments and metasediments and Tertiary and/or Quaternary sediments occur in the Dumont Hills to the southwest. The Nopah Range to the west consists predominantly of Precambrian and Paleozoic sediments and metasediments.

Quaternary alluvium, which is exposed over most of the basin floor, comprises the upper portion of the valley fill. Quaternary lake deposits occur in part along the western edge of the basin adjacent to the Nopah Range.

Water Supply

The principal source of ground water replenishment in California Valley Ground Water Basin is percolation of streamflow originating in the watershed. The basin receives an annual rainfall of about five inches. Surface runoff, derived mainly from the Nopah and Kingston Ranges, drains to the southwest toward Willow Creek which, in turn, joins the Amargosa River.

The alluvial fans of the Nopah and Kingston Ranges are the major recharge areas and are capable of absorbing and transmitting water at a moderate rate. Ground water which is found in Recent and underlying older alluvial deposits follows the same general direction as the slope of ground surface and outflow occurs through the alluvium in Willow Creek.

The depth to water at the Davis Well (20N/9E-6R1) is about 42 feet; at Willow Creek (20N/8E-27Q1), it is about 8 feet. The southwesterly sloping hydraulic gradient between these two wells is about 40 feet per mile.

Development and Utilization. Ground water has been utilized mainly for mining and ranching operations that have been conducted intermittently since the early 1900's. The bulk of the mining activities is on the southwest side of the valley and the two mining camps located there are the headquarters for the lead, silver, zinc, and talc mines. Ground water is obtained from well 20N/8E-27Q1 for use in these mining activities. Ranching is carried on mainly in the form of stock raising. Well 20N/9E-6R1 is used for watering of stock; water from Horse Spring 19N/10E-3C1 is piped two miles to the north for domestic and stock use.

It is estimated that there are about 75 residences in the basin, some of which are only occasionally occupied. The water supply, which is largely extracted from the two known wells, is supplemented by water obtained from springs. An estimated 100 acre-feet of water is annually utilized in the basin.

Water Quality. The ground water in the basin is considered to be suitable for irrigation use but marginal to inferior for domestic use, due to the fluoride concentrations of 1.1 to 1.8 ppm, as shown on Table 28. The total dissolved solids content of the ground water is about 500 ppm. Water from Crystal, Beck, and Horse Springs contains a total dissolved solids content of about 350 ppm and is suitable for all prevailing uses.

Ground water from wells 20N/8E-27Q1 and 20N/9E-6R1 is sodium-magnesium bicarbonate-sulfate in character while water from the springs is magnesium or calcium bicarbonate in character.

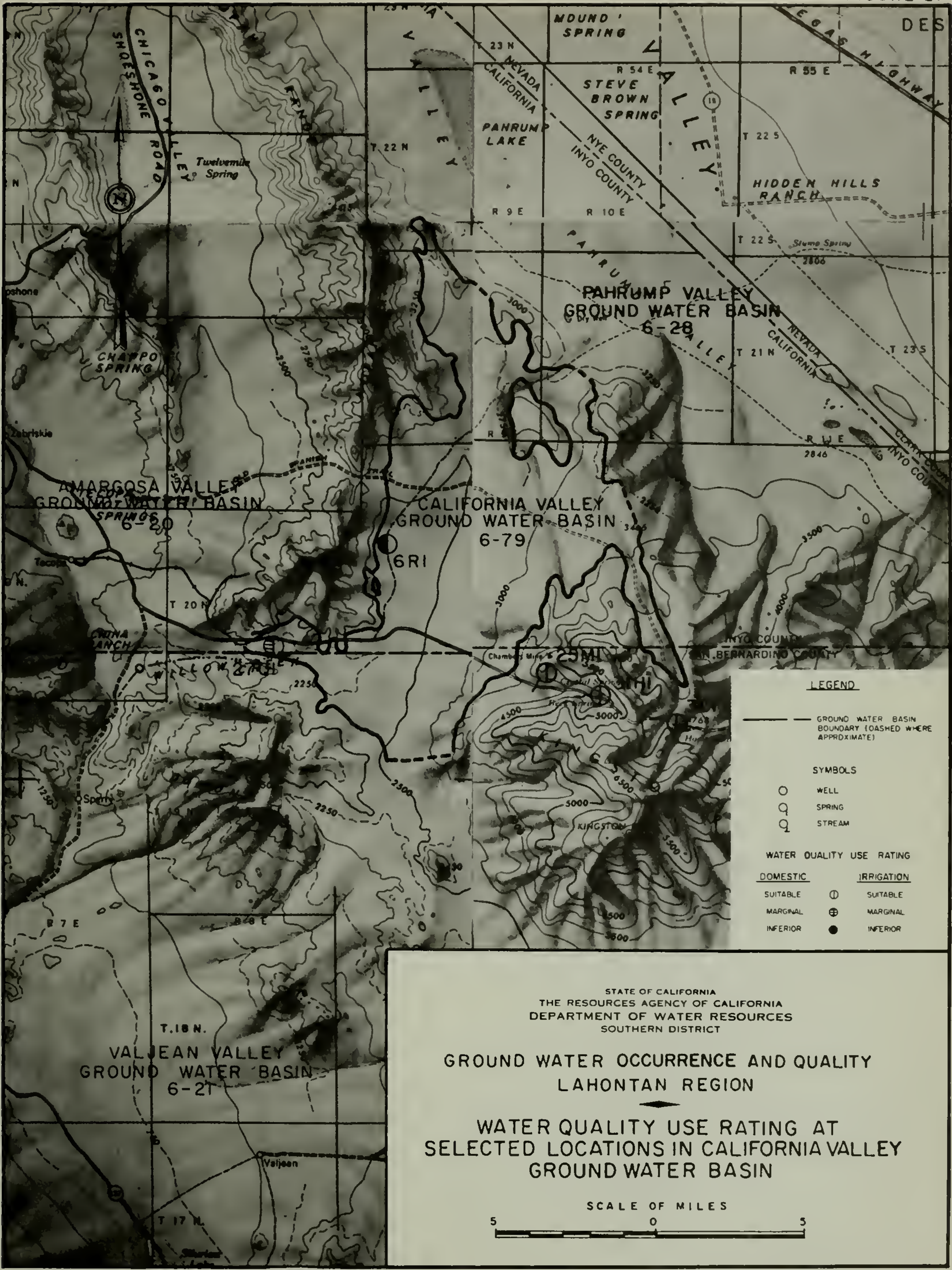
TABLE 28

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
CALIFORNIA VALLEY GROUND WATER BASIN (6-79)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification			Water Quality Use Rating: Basis for Classification		Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
Horse Spring 19N/10E-3C1	DI						Ca HCO_3	4-21-53	flow	Domestic Stock
20N/8E-27Q1	I	D		F		2.2 ± 1.8	Na-Mg HCO_3 - SO_4		$8 \pm$ ft	Municipal Industrial
Davis Well 20N/9E-6R1	I		D		F		Na-Mg HCO_3 SO_4	4-21-53	42 ft	Stock
Crystal Spring -25M1	DI						Mg HCO_3	4-21-53	flow	Domestic
Beck Spring 20N/10E-31H1	DI						Ca HCO_3	4-21-53	flow	Stock

D - Domestic
I - Irrigation

FIGURE 21


STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT SELECTED LOCATIONS IN CALIFORNIA VALLEY GROUND WATER BASIN
SCALE OF MILES
5
0
5
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
SUITABLE
MARGINAL
MARGINAL
INFERIOR
INFERIOR
PAHRUMP VALLEY GROUND WATER BASIN 6-28
CALIFORNIA VALLEY GROUND WATER BASIN 6-79
AMARGOSA VALLEY GROUND WATER BASIN 6-20
VALJEAN VALLEY GROUND WATER BASIN 6-21
6R1
25M1
1H1
MOUND SPRING
STEVE BROWN SPRING
PAHRUMP LAKE
HIDDEN HILLS RANCH
CHAPPO SPRING
Twelvemile Spring
CHICAGO VALLEY
SHOSHONE ROAD
NEVADA
CALIFORNIA
NYE COUNTY
INYO COUNTY
SAN BERNARDINO COUNTY
CLARK COUNTY
VEGAS HIGHWAY
Shoshone
Zabriskie
Tecopa
TECOPA SPRINGS
CHINA RANCH
WILLOW CREEK
KINGSTON
Valjean
T 23 N
T 22 N
T 21 N
T 20 N
T.18 N.
T 17 N.
T 22 S
T 23 S
R 54 E
R 55 E
R 9 E
R 10 E
R 7 E
R 8 E
DES

IVANPAH DRAINAGE BASIN (NO. 18)

Pahrump Valley Ground Water Basin (6-28)

Pahrump Valley Ground Water Basin, shown on Figure 22, is a northwesterly trending rectangularly shaped area of about 400 square miles. The basin extends across the California-Nevada border; the portion of the basin lying within California includes an area of about 146 square miles and is located in the southeastern corner of Inyo County, in the Ivanpah Drainage Basin (No. 18).

The basin is bordered on the west by Resting Spring and Nopah Ranges, and on the south by the Kingston Range. Maximum elevations in the bordering Nopah and Kingston Ranges are 6,400 feet and 7,320 feet respectively. The elevation of the valley floor is approximately 3,000 feet.

The lowest point in the valley is Stewart Lake, at an elevation of 2,457 feet; the lake has an area of about six square miles. Pahrump Lake, also located within the basin, stands at an elevation of 2,512 feet; it encompasses an area of about ten square miles.

Geology

The valley is bordered to the north and east by the Paleozoic and Precambrian sediments and metasediments which predominate in the Spring Mountains; and to the south and west by the same rock units in the Kingston, Nopah, and Resting Spring Ranges.

The Quaternary alluvium is exposed over much of the basin floor, comprising the upper portion of the valley fill, which extends to a depth of at least 800 feet. Pahrump Lake is a dry type of playa; Stewart Lake, a moist type of playa. The dune sand deposits in the southern portion of the basin, and the playa deposits are generally less than 100 feet thick.

Water Supply

The principal sources of ground water replenishment in the basin are percolation of streamflow originating in the watershed and deep penetration of direct rainfall. However, only a small part of the precipitation recharges the alluvial fan and valley fill materials because of evaporation and transpiration losses. The water that reaches the ground water reservoirs is ultimately discharged through springs and wells or by evaporation and transpiration. Estimates indicate that approximately 23,000 acre-feet of water is annually available for recharge.

Records show that the average annual precipitation on the valley floor is less than six inches. There are no perennial streams; most of the streams are intermittent. The only noticeable streamflow occurs below Bennetts Springs which discharges large quantities during the spring months; the resulting stream flows on the surface for several miles before percolating into the ground.

Ground water occurs at shallow depths, ranging to about 50 feet below the surface in the basin lowlands, and near the lower margin of the alluvial fans. At these points, the water is usually under slight artesian pressure; in many places, however, it is unconfined but apparently receives recharge from the underlying confined deep aquifers which appear to be the main source of supply to the valley. Forebay areas for these deeper confined aquifers are the upper reaches of the alluvial fans that fringe the valley.

There is neither surface inflow to, nor outflow from Pahrump Valley. Ground water under natural conditions flows centripetally from the outer rim of the valley toward the dry lakes except where depressions created by the greatest extractions of pumping wells modify the direction of ground water movement. Data indicate that water levels fluctuate in response to withdrawal rates.

Development and Utilization. In the late 1800's and early 1900's, development of the mining industry occurred in the mountains surrounding Pahrump Valley. The settlement of Pahrump obtained water from Bennett's Springs which reportedly flowed at 2,000 gallons per minute. Water was first utilized for irrigation from the springs located at Pahrump and Manse ranches in the late 1870's. Wells drilled to greater depths at these locations in 1915 yielded large artesian flows from lower zones. In 1916, more than 500 acres of alfalfa and grain were irrigated by these springs and wells. An attempt at farming during this period in Stewart Valley failed due to the alkalinity of the soil and an insufficient water supply.

Production of crops increased very slowly until the 1940's when several additional wells were drilled and more land was developed. In 1960, about 3,300 acres of cotton and 400 acres of alfalfa were under irrigation with production still centered in the areas around the Pahrump and Manse ranches. Since the irrigated land at present is on the Nevada side of the ground water basin, it was deemed advisable to include data on water utilization and quality in the entire Pahrump Valley.

Several wells were drilled in the 1950's on the Hidden Hills Ranch in the southern portion of the valley. This is presently the only area on the California side of the valley where wells exist, however, they are not used for irrigation because of relatively poor yield of water and the excessively large drawdown as shown in Diagram 3.

The number of wells in the Nevada side of the valley has increased from 27 in 1916 to 56 in 1946. Thirteen of these wells were flowing in 1916 and 24 in 1946. Since 1960 to the present, well-drilling activity in the basin has increased.

The only significant withdrawal of ground water in the valley for the period 1916-1940 was at the Pahrump and Manse Ranches. The ground water extraction, including Bennett's and Manse Springs, was fairly constant for the period and is estimated to have been about 9,600 acre-feet a year. In the 1940's development increased greatly and the annual ground water withdrawal increased to about 17,500 acre-feet.

Water Quality. The quality of ground water from wells throughout the valley is suitable for all beneficial uses except that from well 20S/52E-6R1, as shown in Table 29. The quality of water from this well is inferior for domestic use because of its fluoride concentration of about 2 ppm. The water has a total dissolved solids of 841 ppm while ground water from the rest of the basin ranges from 176 to 538 ppm. The character of the ground water in the valley varies from calcium-magnesium bicarbonate to magnesium-calcium bicarbonate. The radioactivity level from nine samples ranged from 1.3 to 33.4 pc/l total activity with a median of 3.8 pc/l.

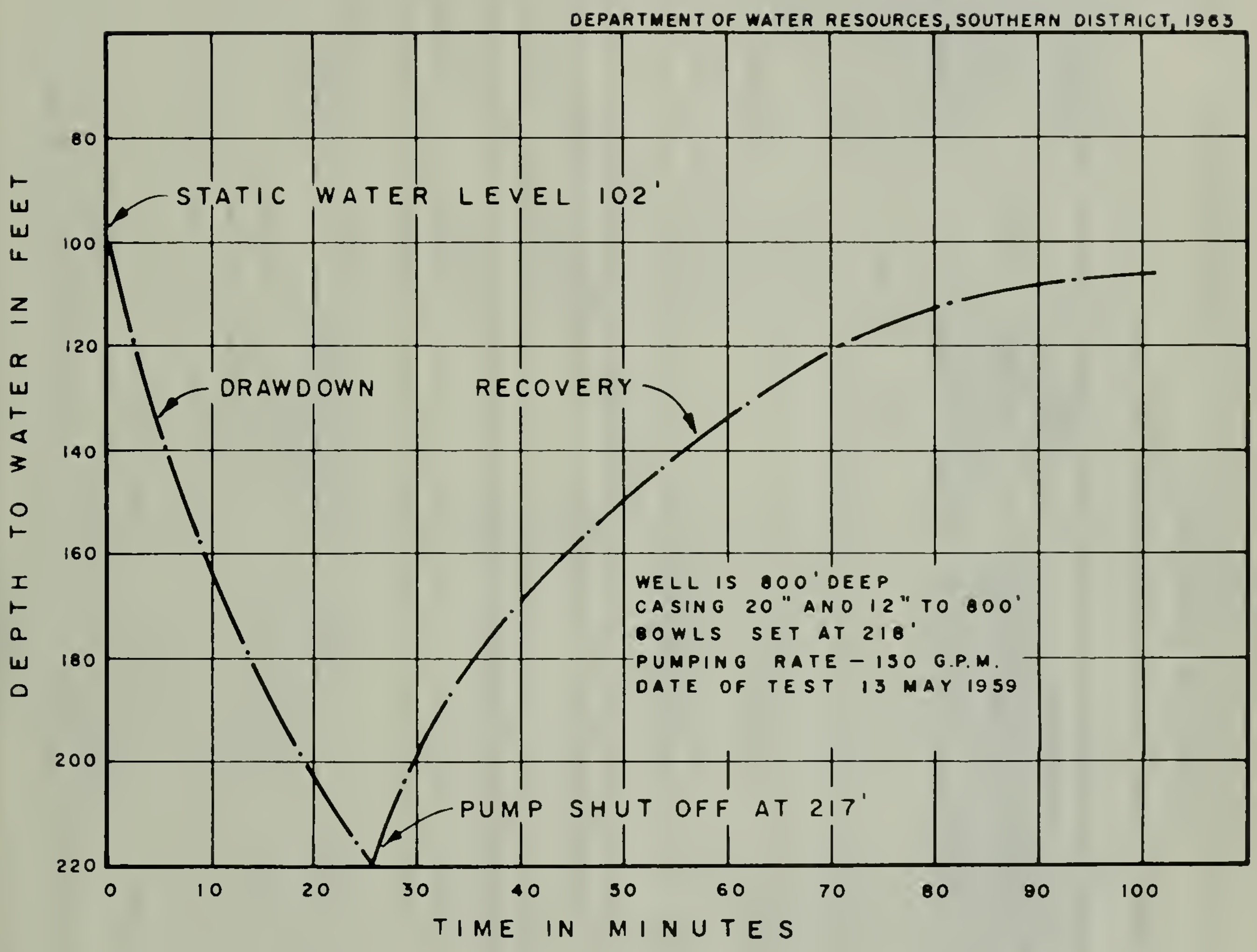


DIAGRAM 3. GROUNDWATER TABLE DRAWDOWN AND RECOVERY AT WELL 22N/10E-33A1 HIDDEN HILLS RANCH, PAHRUMP VALLEY

TABLE 29

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN

PAHRUMP VALLEY GROUND WATER BASIN (6-28)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification			Water Quality Use Rating: Basis for Classification		Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
California 21N/10E-3M1	DI					1.4 ± 0.8	Ca-Mg HCO_3	5-13-59	122.3ft	Unknown
-4L1	DI						Mg HCO_3	5-13-60	164.4ft	Unknown
-11K1	DI						Ca-Mg HCO_3	5-10-57	225.4ft	Unknown
22N/10E-33A1	DI					33.4 ± 1.7	Ca-Mg HCO_3	5-13-59	102 ft	Unknown
24N/8E-28Z1	DI						Mg-Ca HCO_3	1916	38 ft	Destroyed
Nevada 20S/52E-1E1	DI						Ca HCO_3	7-15-46	Surf.	
-6R1	I		D		F	27.6 ± 1.2	Mg HCO_3	5-12-59	9.9ft	Unknown
-35A1	DI					5.8 ± 1.0	Mg HCO_3	5-12-59	23.8ft	Domestic
Pahrump 20S/53E-14Q1	DI						Ca HCO_3	7-18-43	flow	Irrigation
-15H1	DI						Ca-Mg HCO_3	4- 4-44	flow	Domestic Irrigation

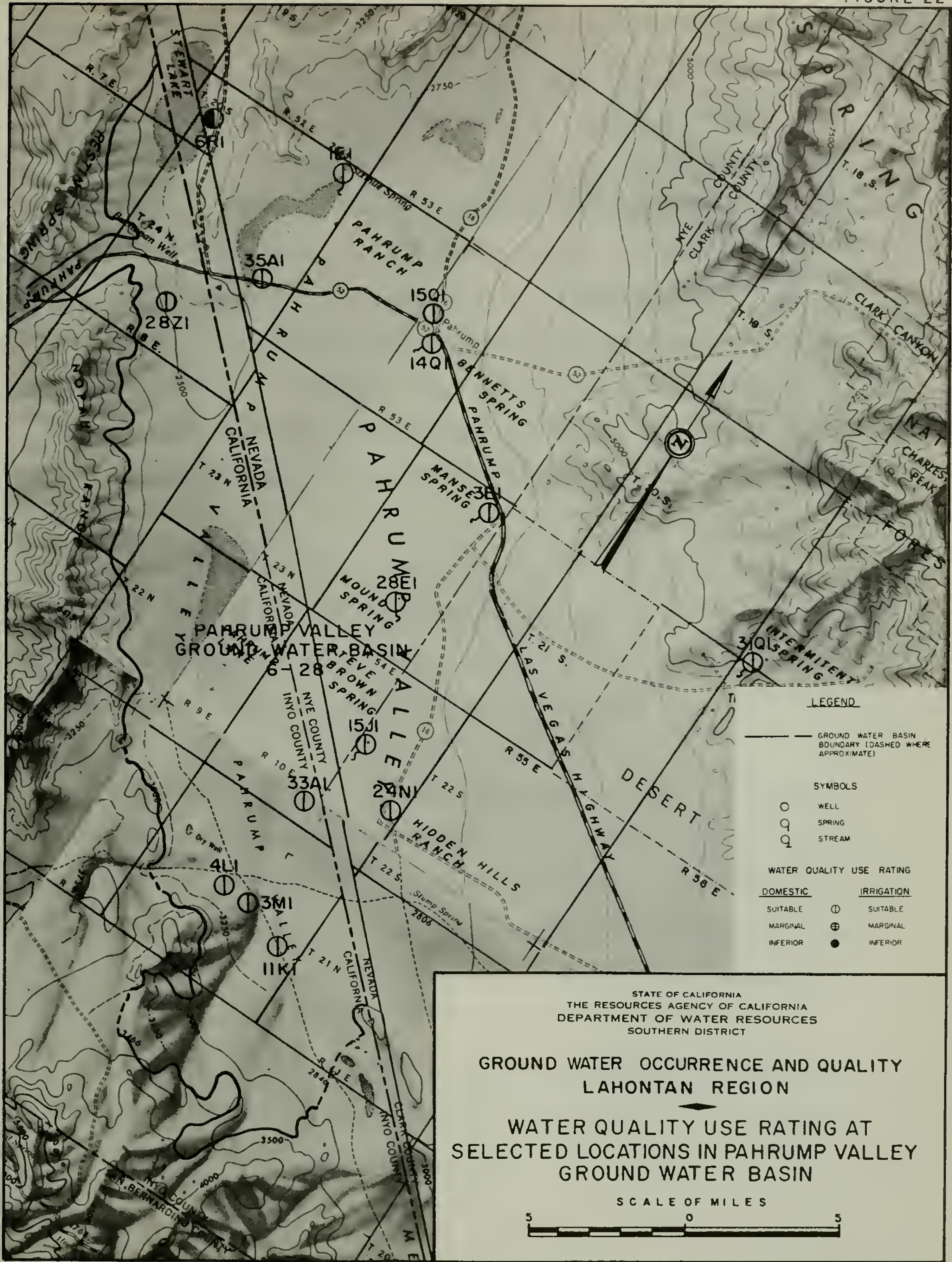
D - Domestic
I - Irrigation

TABLE 29

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
PAHRUMP VALLEY GROUND WATER BASIN (6-28)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Intermittent Spring 20S/56E-31Q1	DI						Ca HCO_3		flow	Unknown
Manse Spring 21S/54E-3E1	DI						Ca HCO_3	1937	flow	Irrigation
Mound Spring -28E1	DI						Ca HCO_3	9-27-55	10.5 ft.	Destroyed
Steve Brown Spring 22S/54E-15J1	DI						Ca HCO_3	5- 5-46	flow	Unknown
Hidden Hills Ranch 22S/54E-24N1	DI						Ca HCO_3	5-13-60	33.5 ft	Domestic

D - Domestic
I - Irrigation



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WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN PAHRUMP VALLEY
GROUND WATER BASIN

SCALE OF MILES
5 0 5

Mesquite Valley Ground Water Basin (6-29)

Mesquite Valley Ground Water Basin, shown on Figure 23, is located along the California-Nevada Border in the Ivanpah Drainage Basin (No. 18). The portion of the basin lying within California is situated in the northeast portion of San Bernardino County, and the southeast corner of Inyo County and includes an area of about 125 square miles. This roughly oval-shaped area is bordered on the northwest by the Mesquite Mountains and Kingston Range and on the south by the Clark Mountains. Although the ground water basin extends into Nevada, for the purposes of this report, the California-Nevada state line is considered the northeast boundary.

Maximum elevation is attained on Kingston Peak, in the Kingston Range, which rises to 7,328 feet. The valley floor ranges in elevation from 2,540 at Mesquite Lake, which is about seven square miles in extent, to about 2,700 feet in the northeast end of the basin.

Geology

Mesquite Valley is bordered on the north by an alluvial high, and to the east and south by Precambrian and Paleozoic sediments and metasediments of Clark Mountain. Similar rocks crop out to the southwest in the Mesquite Mountains, and in the Kingston Range to the northwest. However, the core of the mass that culminates in Kingston Peak consists of pre-Tertiary granitic rocks.

The Quaternary alluvium is exposed over much of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 1,180 feet.

Water Supply

The principal source of ground water replenishment in Mesquite Valley Ground Water Basin is percolation of streamflow originating in the watershed. The annual rainfall ranges from about three inches on the valley floor to nine inches on the higher peaks of the surrounding mountains. The surface waters flow down numerous channels, from the outer edges of the valley, centripetally towards Mesquite Lake. There are no major river channels in the basin, and there is neither surface inflow from, nor outflow to, external valleys.

The ground water basin is recharged at a moderate rate through the alluvial fans which fringe the valley. Usable supplies of ground water are derived from the Recent and underlying older alluvial deposits. Ground water moves in the same general direction as the slope of the land surface, that is, towards the dry lake where a slight pressure area exists. Diagram 4 depicts the general slope of the ground water table. Depth to water varies from ten feet below the surface near the dry lake, to 129 feet in the northern portion of the valley. The water table gradient slopes toward the dry lake from the north end of the valley at a rate of about 3-1/2 feet per mile. The natural movement of the ground water is altered by water level depressions caused by pumping wells. Well 19N/12E-14M1 is reported to have a drawdown of 125 feet at a pumping rate of 1,500 gpm and is believed to be representative of wells in the valley.

Development and Utilization. The early valley residents were involved in the mining operations which occurred mainly in the Spring Mountains. Mining became so important that by the early 1900's there were

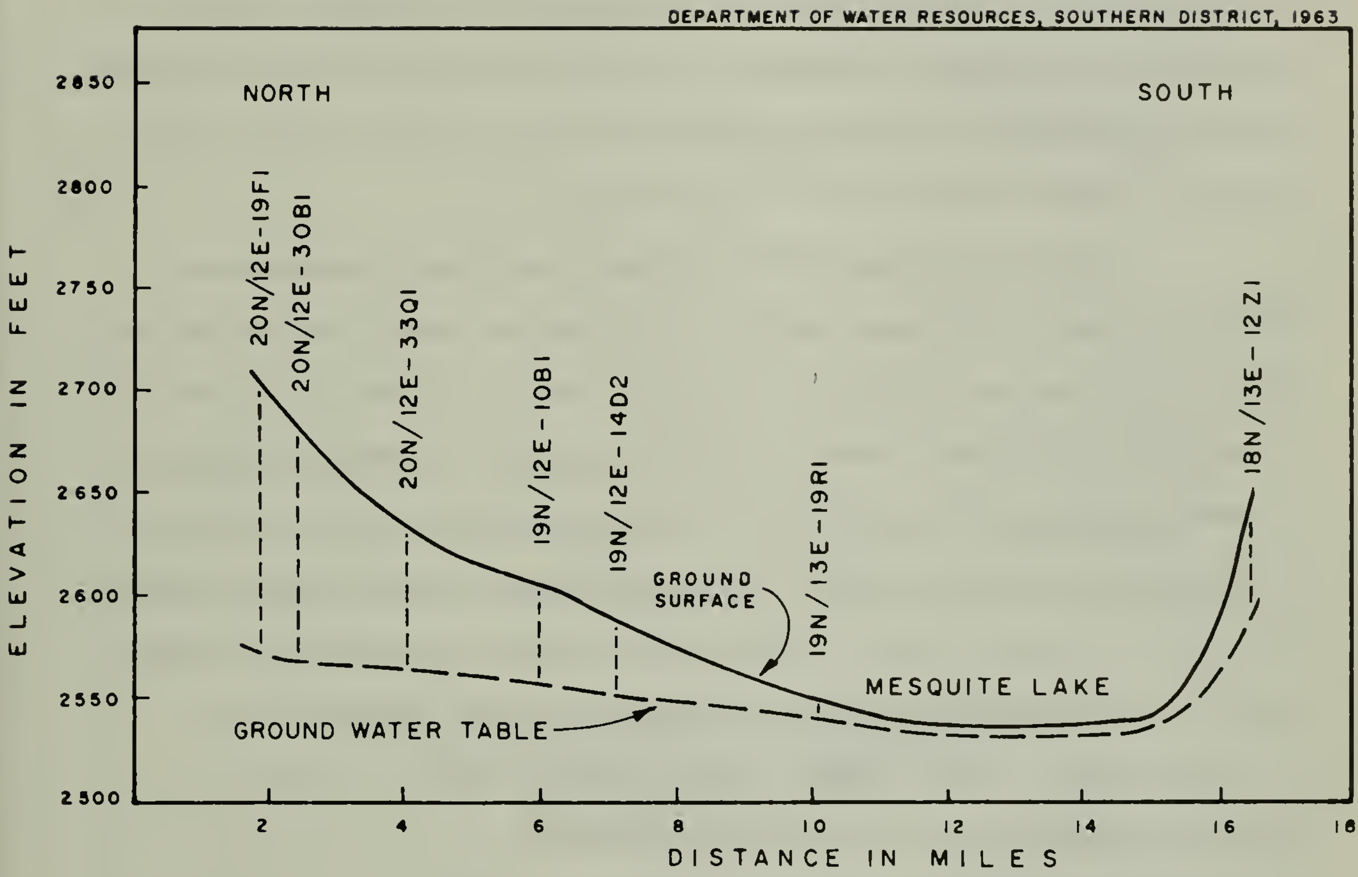


DIAGRAM 4. SECTION THROUGH GROUND WATER TABLE IN MESQUITE VALLEY

several thousand people working and living in the valley. Because water of inferior quality was encountered around Mesquite Lake, the main development occurred in the north-central portion of the valley where better water was found. In 1916, 34 wells are known to have existed, most of which were dug. Most of these wells have since been destroyed or replaced with drilled wells and at present there are about 40 wells in the valley. About 25 people presently reside in the valley.

During the period 1910-14 several unsuccessful attempts were made to irrigate with ground water on an extensive scale. The failure of these operations was attributed to the poor quality of the soil rather than that of the ground water. In 1916 a few acres of alfalfa were successfully grown, however, very little farming was done prior to 1952 when several more wells were drilled for irrigation use. Approximately 2,200 acres of land were cleared on the California side of the valley in preparation for irrigation during the period 1953-55, but few acres have produced a crop. In the summer of 1955 about 300 acres of cotton were under irrigation and in 1958, 724 acres of castor beans, alfalfa, and pasture were being irrigated. Based upon these production figures, the annual ground water extraction from the basin is estimated to be about 4,000 acre-feet per year. The present extraction is believed to be within the safe yield because water levels have varied only a few feet within the period of record.

Ground Water Quality

The ground water obtained in the northern half of the valley is generally of suitable quality but the water from the southern half in the area of Mesquite Lake is generally of marginal to inferior quality as shown on Table 30. The character of the ground water varies greatly within the basin, however, calcium and magnesium are generally the predominant cations and bicarbonate is generally the major anion. Ground water from the area around Mesquite Lake is sodium chloride in character. According to owners and drillers, several wells drilled to depths of 700 feet or more, and producing from these deeper zones, have yielded water unsuitable for irrigation.

The total dissolved solids content of the ground water from the northern half of the valley generally varies from 300 to 500 ppm while the ground water from the southern half of the valley generally varies from 1,000 to 1,500 ppm. During the period 1953-60, in the central portion of the valley, the water quality analyses showed degradation has occurred in ground water from four wells and improved in two of the wells as shown in the tabulation below:

CHANGES IN WATER QUALITY AT SELECTED WELLS
IN MESQUITE VALLEY GROUND WATER BASIN

Well number	Date	T.D.S.	SO_4	CL	Na
		Degraded Waters			
25S/57E-5G1	10- 5-53	412	123	8	12
	5-14-60	1056	504	49	67
19N/12E-2M1	9-28-55	402	134	11	14
	5-14-59	882	207	195	26
-14C1	5-20-58	969	337	197	128
	5-14-59	6293	684	2915	1610
-14M1	9-12-53	433	124	20	30
	5-14-59	1159	130	479	299
		Improved Water			
19N/12E-23H1	11-15-56	2052	294	746	373
	5-14-60	1167	219	445	232
-26H1	9-11-53	1301	466	254	1280
	12- 8-59	900	223	157	

With the exceptions shown in this tabulation, the quality of the ground water from all other wells in the basin has remained fairly constant.

TABLE 30

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
MESQUITE VALLEY GROUND WATER BASIN (6-29)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
Mesquite Lake 18N/13E-8Q1		D	I	F, EC, TDS,	Cl		Na Cl	5- 7-54 5-12-57	40.4 ft 37.6 ft	Stock
-12Z1		D	I	EC, TDS, % Na	Cl		Na Cl	1916	52 ft	Domestic
19N/12E-2M1	DI						Mg-Ca Cl-SO_4	5-20-55 5-14-59	33.4 ft 32.7 ft	Irrigation
-3BI	DI						Mg-Ca HCO_3	5-20-55 5-20-58	39.8 ft 40.2 ft	Unknown
-4B1	DI						Mg-Ca HCO_3			Irrigation
-10B1	DI						Mg SO_4-HCO_3	9-28-55 5-14-60	45.2 ft 45.3 ft	Irrigation
-11B1	I	D		F			Mg HCO_3	9-28-55 5-14-60	31.4 ft 30.4 ft	Irrigation
-13D1		DI		Cl, EC, TDS, % Na			Na Cl	5-12-57	33.3 ft	Unknown
-14C1			DI	% Na	EC, TDS, Cl SO_4		Na Cl	5-20-58 5-14-59	33 ft 33.8 ft	Irrigation
-14D2	DI						Mg SO_4-HCO_3	5-20-55 5-14-60	37.5 ft 37.0 ft	Domestic

D - Domestic
I - Irrigation

TABLE 30

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
MESQUITE VALLEY GROUND WATER BASIN (6-29)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
19N/12E-14M1		DI		EC, TDS, % Na Cl			Na Cl	9-12-53 5-14-60	35.4 ft 33.9 ft	Irrigation
-15N2	DI						Mg HCO_3	5-12-57 5-14-59	57.7 ft 58.9 ft	Domestic Irrigation
-23A1		DI		Cl, F, EC, TDS			Na Cl			Domestic
-26H1	I	D		F		7.4 ± 1.8	Na-Mg SO_4-Cl	9-11-53 12- 8-59	48.0 ft 47.0 ft	Domestic
-26J1	I	D		F			Na-Mg HCO_3-Cl	5-14-59	67 ft	Irrigation
19N/13E-19P1		D	I	EC, TDS, F, SO_4	Cl, % Na		Na Cl	5- 7-54	14.6 ft	Domestic
-19R1		DI		EC, % Na, F			Na Cl	5-14-59	10.0 ft	Stock
20N/12E-19F1	DI						Mg-Na, HCO_3	5-23-56 5-14-60	127.9 ft 129.3 ft	Irrigation
-29M1	DI					0 ± 1.76	Ca-Mg HCO_3			Irrigation
-30B1	DI					$5.6 \pm 1.0(\beta)$	Ca-Mg SO_4	11-15-56 6-20-60	109.3 ft 112.7 ft	Unknown

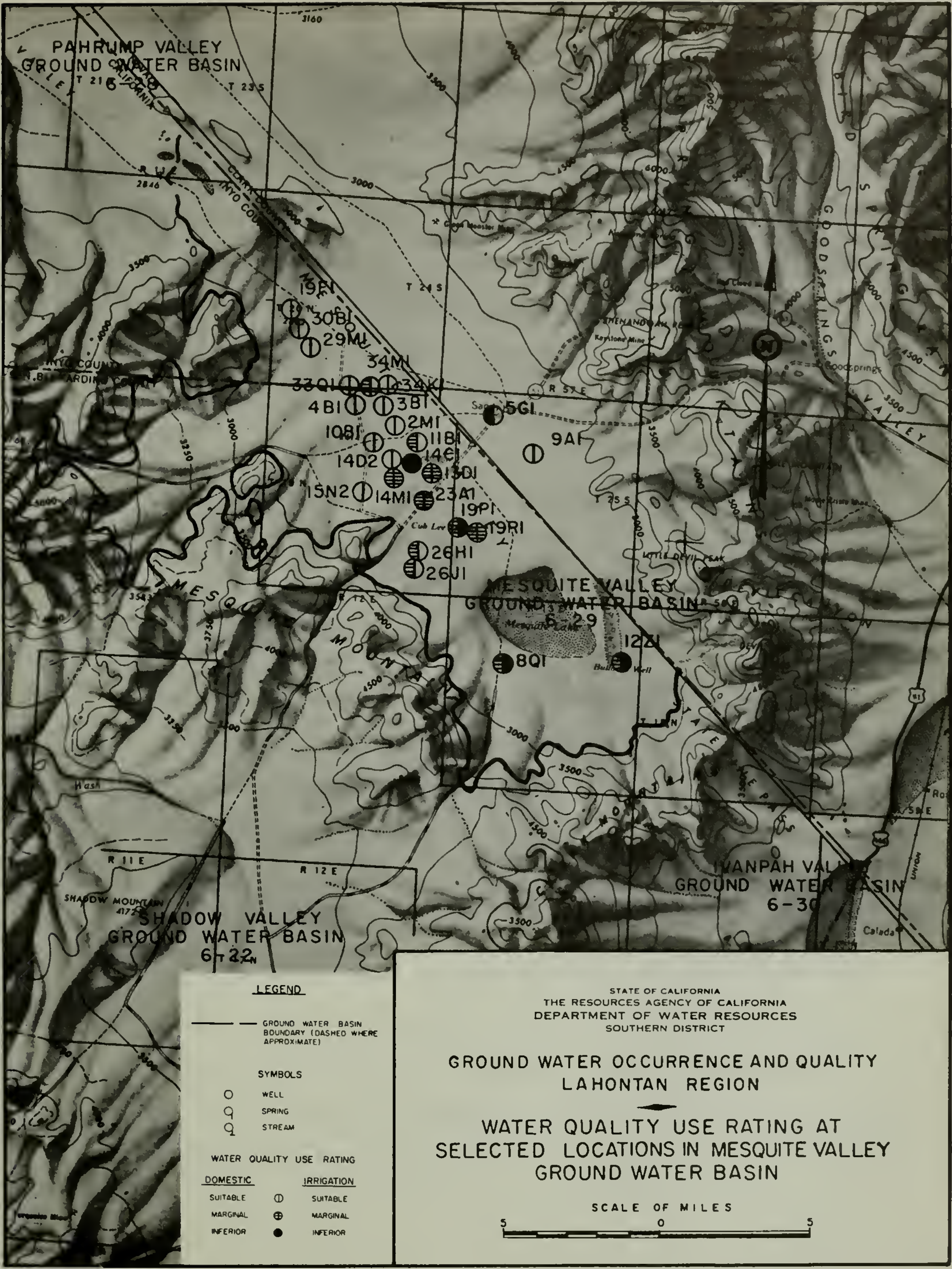
D - Domestic
I - Irrigation

TABLE 30

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
MESQUITE VALLEY GROUND WATER BASIN (6-29)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
20N/12E-33Q1	DI						Mg-Ca HCO_3	11-15-56	67.7 ft	Irrigation
-34K1	DI						Ca-Mg HCO_3	5-20-55 5-14-59	40.8 ft 41.1 ft	Irrigation
-34M1	I	D		SO_4			Mg-Ca SO_4	5-20-55 5-14-59	51.6 ft 52.9 ft	Irrigation
Sandy, Nevada 25S/57E-5G1	I		D	TDS	SO_4		Mg-Ca HCO_3	9-11-53 5-14-59	41.8 ft 48.5 ft	Domestic
-9A1	DI					6.8 ± 1.8	Mg-Ca HCO_3	12- 8-59	47 ft	Domestic

D - Domestic
I - Irrigation



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WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN MESQUITE VALLEY
GROUND WATER BASIN

Ivanpah Valley Ground Water Basin (6-30)

Ivanpah Valley Ground Water Basin shown on Figure 24, occurs in the northeast portion of San Bernardino County and is the southernmost ground water basin in the Ivanpah Drainage Basin (No. 18). The northern part of the basin extends into Nevada. The portion lying within California is a northerly trending area of about 303 square miles.

The basin is bordered by the Clark Mountains on the northwest, by the Ivanpah Range on the west, by the New York Mountains on the southeast, and by the California-Nevada State line on the northeast. Maximum elevation is attained on Clark Mountain which rises to 7,900 feet. Elevation of the valley floor varies from a low of 2,595 feet at Ivanpah Lake, to about 4,000 feet at the southern end of the basin.

Geology

The basin is bordered to the north and northwest by Paleozoic sediments of the Clark Mountains, to the southeast by pre-Tertiary granitic and metamophic rocks of the New York Mountains, and to the southwest by pre-Tertiary granitic rocks of the Ivanpah Mountains.

The Quaternary alluvium is exposed over much of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 825 feet. Ivanpah Lake is a dry type of playa which has a hard clay surface, and an area of about 31 square miles.

The surrounding mountains are highly faulted and the valley is traversed by several prominent northwesterly trending faults which may act as barriers to ground water movement.

Water Supply

The sources of ground water replenishment to Ivanpah Valley Ground Water Basin are deep penetration of direct precipitation and percolation of streamflow originating in the watershed.

The valley floor receives an annual precipitation of three to four inches, increasing to about ten inches at higher elevations in the surrounding mountains; at the higher levels precipitation frequently occurs in the form of snow. The surface flows are all directed centripetally toward Ivanpah Lake. There are no main channels and there is probably neither surface inflow from, or outflow to surrounding areas.

The ground water basin is recharged at a moderate to high rate through Wheaton Wash and the alluvial fans. Ground water in the Recent and underlying older alluvial deposits moves in a northerly direction toward Las Vegas, Nevada. Faults, which are noticeable at the surface east of Ivanpah Dry Lake, may act as partial barriers to ground water movement. Although water level elevations are varied in this locale, the predominant ground water movement is toward the north. Ground water from Ivanpah Valley may possibly seep through to Las Vegas Valley whose water levels are much lower in elevation. It may be possible that the leakage is sufficient from Ivanpah Valley so as to balance the relatively small annual ground water recharge and thereby keep the water table down in the valley. A pressure area exists in the general vicinity of Ivanpah Lake.

The depth to water, excluding springs, varies from about 15 to 34 feet near Wheaton Wash (16N/14E-23Q1) to over 500 feet at Nipton (16N/16E-33M1). The depth to water in the vicinity of the dry lake is

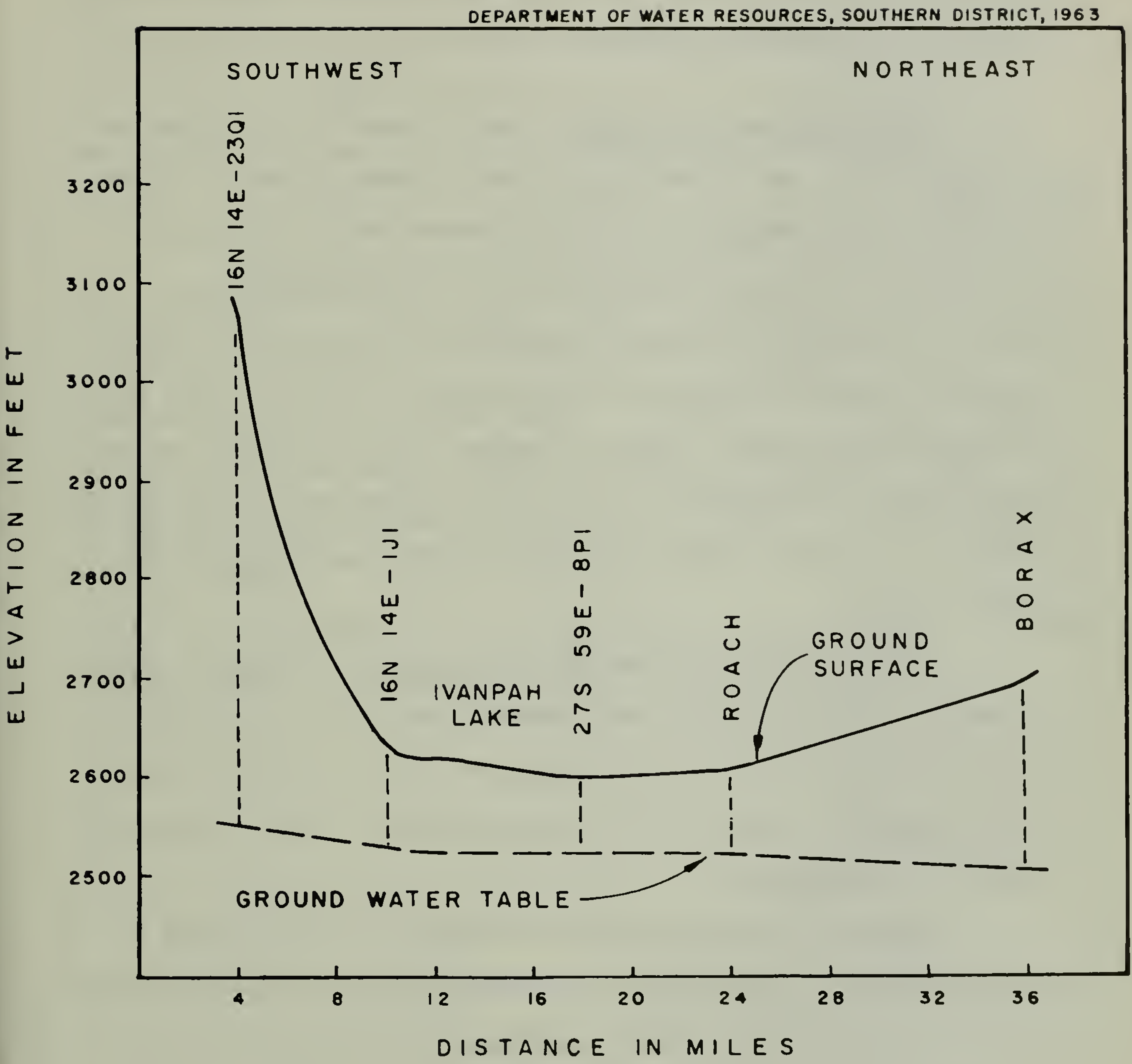


DIAGRAM 5. SECTION THROUGH GROUND WATER TABLE IN IVANPAH VALLEY

about 90 feet. The water table gradient from the County Maintenance Yard (15N/15E-13G1), just north of Ivanpah, to Borax Siding in Nevada, is about 2 feet per mile as shown on Diagram 5.

Development and Utilization. The development of the valley has been slight, mainly due to the lack of water of suitable quality. In the early 1900's mining enterprises and small ranches obtained reliable, but small, supplies of water from springs in the surrounding mountains. Attempts at irrigation were made, but proved to be unsuccessful because the depth to water was too great in the portions of the valley where suitable soil conditions exist. Where the pumping lift is the least, impaired ground water is encountered and the soil is too clayey and too alkaline for successful cultivation. There is no known irrigated agriculture in the valley at present.

Most of the wells in the valley are located along Highway 91-466 or along the Nipton Road. The total number of wells has increased very little during the last 40 years; 16 wells were known to exist in 1919 and in 1960 there were 19 wells. The valley is estimated to have a population of about 100 inhabitants.

Ground water extracted from the valley is relatively small in quantity with well 15 1/2N/15E-20J1 probably extracting the greatest amount. The water from this well is piped approximately 8-1/2 miles to the Mountain Pass Mine of the Molybdenum Corporation which mines rare earths. The rest of the wells are mainly utilized for domestic or stock watering purposes. The annual ground water extraction is estimated to be about 200 acre-feet per year.

Water Quality. The majority of the ground water produced from Ivanpah Valley is marginal to inferior in quality, largely because of the high concentration of fluoride (up to 9 ppm) and percent sodium (up to 97 percent). The ground water generally has a total dissolved solids content of 300 to 500 ppm which has remained fairly constant for the period of record with the exception of wells 16N/14E-31L1 and -31L2 in Wheaton Wash.

Sluicing waters from the Mountain Pass Mine in Wheaton Wash have caused water levels to rise in wells 16N/14E-31L1 and -31L2, located downstream from the mine; these waters may also be impairing the common ground water supply downstream from the mine. The total dissolved solids content of ground water from these two wells increased from about 700 to 1,700 ppm, and the chloride ion jumped from less than 100 to over 500 ppm during the period 1954-1960.

The character of ground water varies as shown in Table 31. Sodium chloride waters are generally encountered in the area around the dry lakes.

TABLE 31

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN IVANPAH VALLEY GROUND WATER BASIN (6-30)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
NW of Cima 14N/13E-13H1	DI						Ca-Na HCO_3	5-15-60	14.4ft	Domestic
Cut Spring -23R1	DI						Ca-Na HCO_3	11- 6-17	flow	Domestic
Kessler Spring 14N/14E-18E1	DI						Ca HCO_3	8-23-16	flow	Domestic Stock
Slaughterhouse Spring 14N/16E-4N1	DI						Ca HCO_3	5-16-60	flow	Stock
-9A1		I	D	EC, TDS	SO_4		Ca-Mg SO_4	5-22-58	166.2ft	Stock
15N/15E-13G1		D	I	F	% Na		Na HCO_3	5-15-59	370 ft	Domestic
Wheaton Spring 15 1/2N/14E-21K1	I	D		F		*34	Mg-Ca HCO_3	9- 2-60	flow	Domestic
15 1/2N/15E-20J1		I	D	% Na	F	8.3 ± 0.9	Na Cl	11-16-56	167.8ft	Mining
-21G1		I	D	% Na	F		Na Cl	5-13-57	96.5ft	Domestic Irrigation
-21L1		I	D	% Na	F		Na Cl	5-15-59	96 ft	Domestic

D - Domestic
I - Irrigation

*Beta-gamma

TABLE 31

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
IVANPAH VALLEY GROUND WATER BASIN (6-30)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Murphy Well 15 1/2N/15E-23N1	I	D		F		4.66 ± .84	Na-Mg HCO_3	5-15-59	102.2ft	Stock
-23P1			DI	% Na	EC, TDS, Cl SO_4		Na Cl	5-15-59	106 ft	Test Well
16N/13E-13G1	I	D		F		27 (B,α)	Ca-Mg HCO_3			Domestic
Mountain Pass Station -14J1	DI						Ca-Mg HCO_3	5-15-60	280.9ft	Domestic
16N/14E-1J1	DI						Na-Ca HCO_3	5-15-60	102.7ft	Domestic
-23Q1	I	D		F			Na-Mg Cl-HCO_3	5-24-56	est. 516 ft	Domestic
-31L1		D	I	F, TDS, EC	Cl		Ca-Mg Cl	9-15-54 5-15-59	84.8ft 21.5ft	Domestic
-31L2		D	I	F, TDS, EC	Cl		Ca-Mg Cl	9-28-55 5-15-60	25.8ft 34.0ft	Domestic
16N/15E-12Q1	I	D		F			Na Cl-HCO_3	12-30-53	325 ft	Railroad
Nipton 16N/16E-33M1		D	I	F	% Na		Na HCO_3-Cl	5-15-59	500+ ft	Domestic

D - Domestic
I - Irrigation

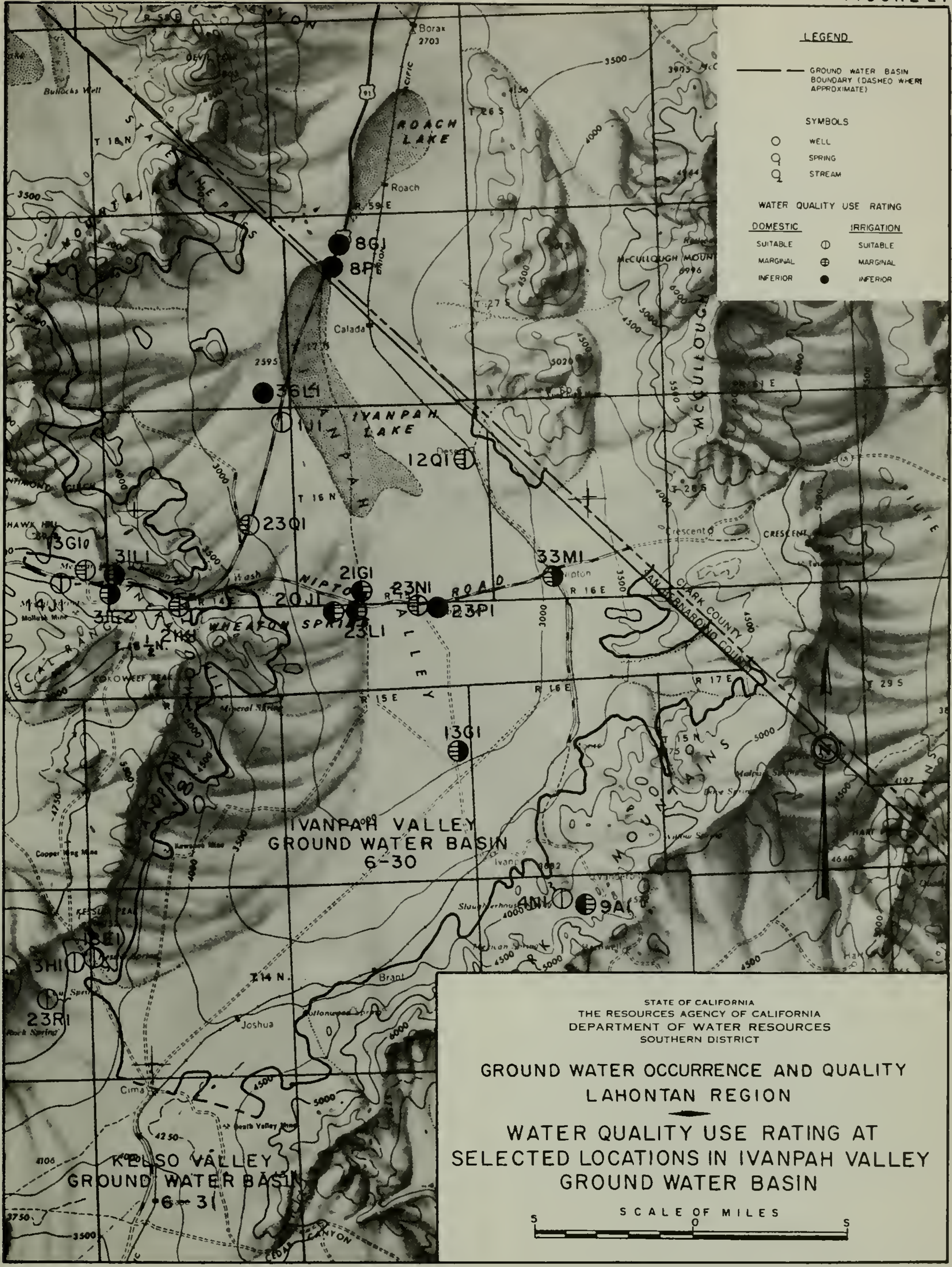
TABLE 31

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
IVANPAH VALLEY GROUND WATER BASIN (6-30)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
17N/14E-36L1			DI		% Na, EC, SO_4 Cl, F, B, TDS		Na Cl	5-21-55	est. 90 ft	Stock
Nevada Wells 27S/59E-8G1			DI		% Na, EC, SO_4 Cl, F, B, TDS		Na Cl	5-21-58	117.5ft	Test
-8P1			DI	B	% Na, EC Cl, F, TDS		Na Cl			Domestic

D - Domestic
I - Irrigation

FIGURE 24



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SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN IVANPAH VALLEY
GROUND WATER BASIN

MOJAVE RIVER DRAINAGE BASIN (NO. 19)

Kelso Valley Ground Water Basin (6-31)

Kelso Valley Ground Water Basin, shown on Figure 25, is a northeasterly trending, irregularly shaped area of about 371 square miles, located in the east central portion of San Bernardino County. The basin is the easternmost valley in the Mojave River Drainage Basin (No. 19).

This basin is bordered on the north by the Marl Mountains and Teutonia Peak; on the east by the Providence Mountains; on the south by the Granite, Old Dad, and Bristol Mountains; and on the west by the Kelso Mountains. The Kelso Mountains rise to elevations in excess of 4,700 feet on the west; to the east, the Providence Mountains attain a maximum elevation of about 7,000 feet. The valley floor ranges in elevation from 1,500 feet in the southwest portion, to 4,000 feet at the northern limits.

Geology

The mountains surrounding Kelso Valley are varied in origin and type. The valley is partially bordered on the north and west by alluvial highs which probably reflect buried bedrock ridges of pre-Tertiary granitic and metamorphic rocks; these rocks also occur in the Teutonia Peak area and in the Granite Mountains. Similar type rocks and Paleozoic sediments occur in the Providence Mountains. The Old Dad and Bristol Mountains consist largely of pre-Tertiary granitic and Tertiary volcanic rocks.

Quaternary alluvium is exposed over much of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 1,970 feet near Kelso. Sand dunes covering an area of about 10 to 15 square miles occur about five miles southwest of Kelso.

These dunes, some of which are 500 feet in height, are the largest in the Lahontan Region. The Cedar Canyon fault, for most of its length, roughly parallels the northeasterly trend of the axis of Kelso Valley. The fault is concealed except where it crosses the highlands.

Water Supply

The basin is recharged by percolation of rainfall and runoff. Precipitation averages not more than three to four inches annually in the lower elevations, although on the higher parts of the New York and Providence Mountains, the rainfall may be as much as ten inches per year. The valley has no surface inflow from external sources, and there are no perennial streams. Kelso Wash, the principal drainage channel, is subject to flash floods during infrequent thunderstorms.

Ground water in the Recent and underlying older alluvial deposits moves in a southwesterly direction, parallel to the general route of Kelso Wash. The depth to water at Sands, which is about 18 miles west of Kelso, is about 200 feet, and the depth to water at Kelso is about 420 feet.

Pumping wells at Kelso have large drawdowns indicating a poor or low yielding aquifer. Well 11N/12E-25G1 had a reported drawdown of 170 feet while pumping at the rate of 375 gpm or a specific capacity of about 2.2 gpm per foot of drawdown. The water level of this well recovered from a depth of 470 feet in 1954 to a depth of 420 feet in 1961.

Development and Utilization. The development of the valley was based primarily on railroad activities; mining and livestock raising were undertaken only in a limited way. Kelso is the main railroad station and in the past all trains stopped for fuel at this site. Water at Kelso is obtained from wells and in addition, in the past, a reserve supply was piped from Cornfield Spring to a reservoir near Kelso. Water is utilized by the Union Pacific Railroad and by an estimated resident population of 100 for domestic purposes.

There are now two wells at Kelso, numbered by the railroad as numbers 8 and 9, but in 1918, water was obtained from well numbers 1, 2, and 3, possibly indicating that at least nine wells were drilled to date at Kelso. There is no record of any other wells in the valley. The estimated ground water extraction for the valley is about 50 acre-feet per year.

Ground Water Quality

The ground water obtained at Kelso has a total dissolved solids content of 570 ppm and is suitable for all beneficial uses, as shown on Table 32. It is sodium bicarbonate-sulfate in character and has a recorded radioactivity level of 3.7 pc/l. There have been no adverse quality changes and no problems due to waste discharges.

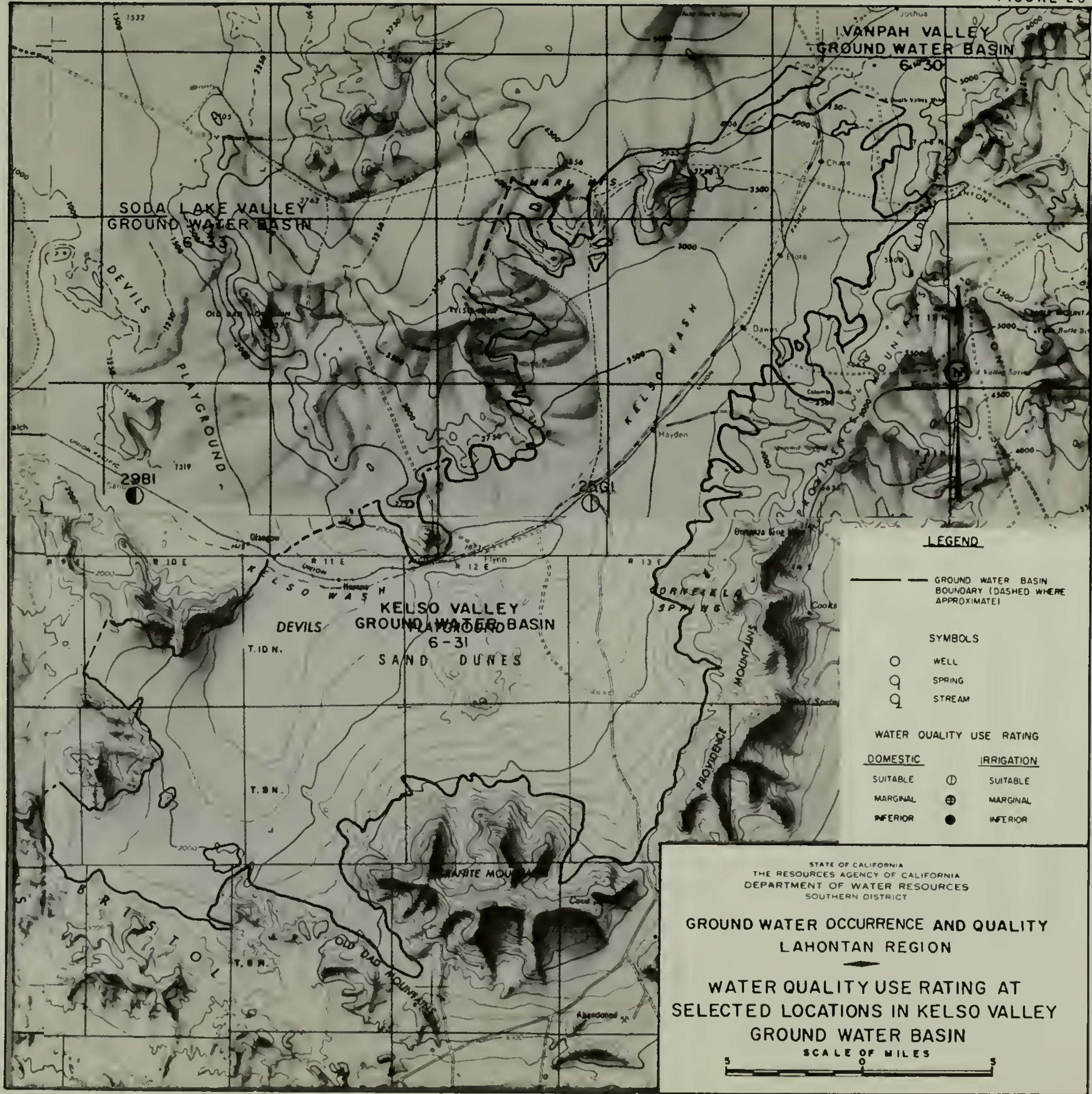
TABLE 32

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
KELSO VALLEY GROUND WATER BASIN (6-31)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
Kelso 11N/12E-25G1	DI					3.7 $\pm$ 0.9	Na HCO_3-SO_4	5-11-61	420.3 ft	Domestic

D - Domestic
I - Irrigation

FIGURE 25



STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN KELSO VALLEY GROUND WATER BASIN

SCALE OF MILES
5 0 5

Broadwell Valley Ground Water Basin (6-32)

Broadwell Valley Ground Water Basin, shown on Figure 26, is a rectangularly shaped, northerly trending area of about 119 square miles. Located in San Bernardino County, in the southern part of the Lahontan Region, the basin lies within the Mojave River Drainage Basin (No. 19).

This basin is bordered on the northwest by the Cady Mountains, on the northeast by the Bristol Mountains, on the southeast by the Bullion Mountains, and on the southwest by Mt. Pisgah. The surface drainage divide between the Lahontan Region and the Colorado River Region, No. 7 follows the crest of the Bullion Mountains.

Maximum elevation in the mountains bordering the basin is attained by the Cady Mountains which rise to 4,627 feet. The valley floor slopes centripitally from an elevation of about 2,000 feet toward Broadwell Lake which stands at an elevation of 1,296 feet above sea level. Broadwell Lake includes an area of 3.5 square miles.

Geology

The Bristol Mountains on the northeast and east are composed of pre-Tertiary granitic rocks, Tertiary volcanic rocks and sediments, and Quaternary volcanic rocks. The Bullion Mountains to the southeast consist largely of Tertiary volcanic rocks with some Quaternary volcanic rocks. Mount Pisgah is a volcanic crater which lies north of Lavic Lake. The Cady Mountains along the western and northwestern border are composed of Tertiary volcanic rocks and/or sediments and undifferentiated crystalline rocks.

The valley floor is underlain by Quaternary alluvium except for the playa deposits at Broadwell Dry Lake; the alluvium comprises the upper portion of the valley fill which extends to a depth of at least 1,600 feet.

The general trend of the faults in the bordering highlands is predominantly northwesterly, although several small northeasterly trending faults occur in the Cady Mountains.

Water Supply

The principal source of recharge to the basin is percolation of precipitation and runoff. The annual rainfall for Broadwell Valley is estimated to be three inches. Alluvial fans from the Bullion and Cady Mountains are the main recharge areas for the valley and their capacity is rated moderate to high.

There have been only a few wells in the valley and the water level records for these wells are sparse. Ground water in the Recent and older alluvial deposits moves from the outer portions of the basin toward the dry lake. The alluvial fill in the pass to Soda Lake Valley Ground Water Basin may be of sufficient depth to permit subsurface outflow northward.

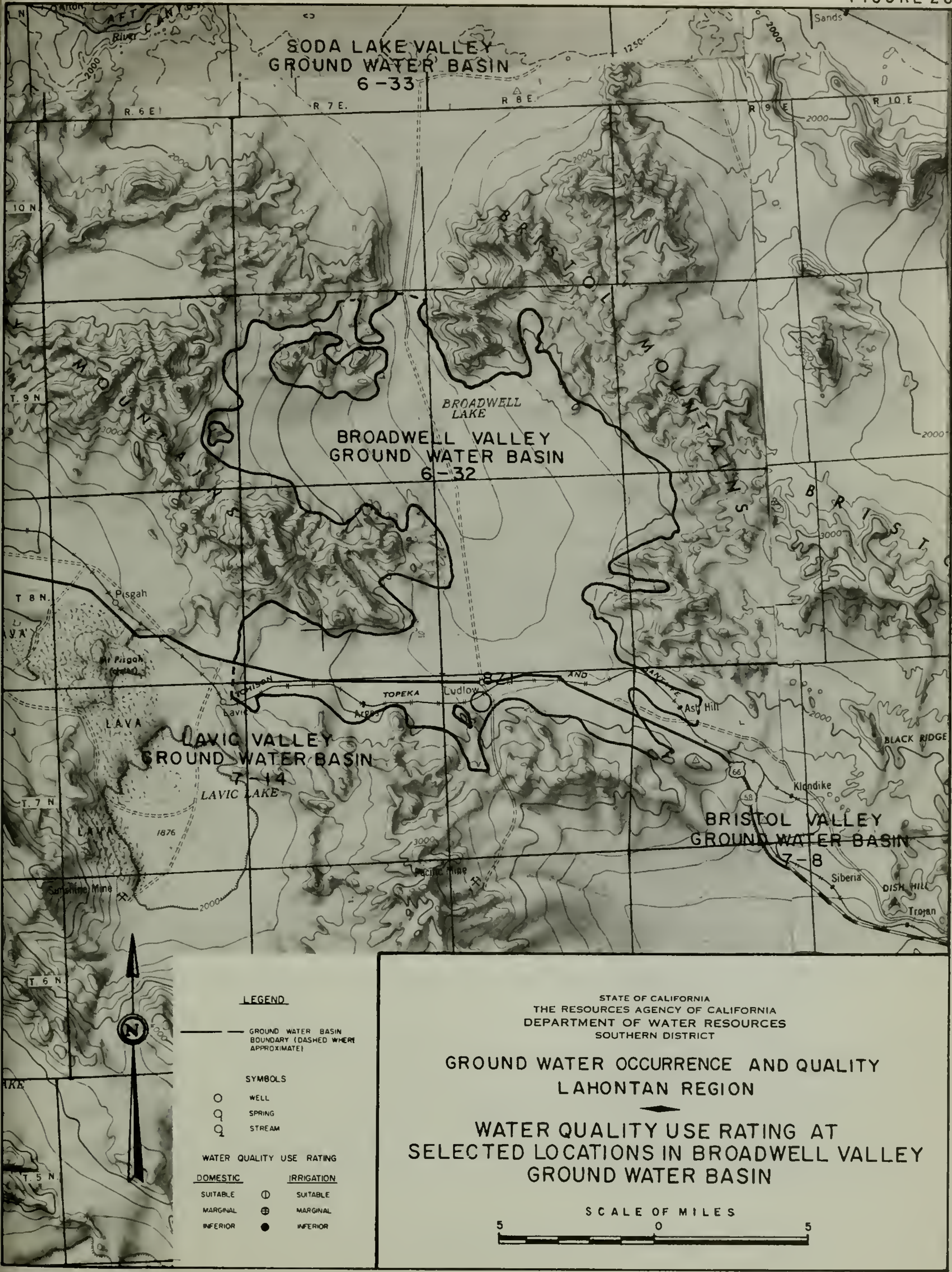
A 1,600 foot cased well (7N/8E-8Z1) drilled at Ludlow in March 1883 struck water initially at 785 feet; as drilling continued, water was again struck at 1,084 feet below the ground surface. If the top water-bearing zone is continuous, northwards toward Soda Lake Valley, depth to water under Broadwell Lake would be approximately 300 feet.

Development and Utilization. In 1917 Ludlow had a population of approximately 200 to 300. Early development was due largely to mining activities in the Cady and Bullion Mountains, and to tourist travel on U.S. Highway 66 and the Atchison Topeka and Santa Fe Railroad, both of which pass through the basin area.

In 1919, almost 170,000 gallons of water was hauled daily by the railroad from Newberry into Ludlow Springs to provide for the water requirements. Presently, there are five known wells in the basin, all of which are dry, except the 1,600 foot deep well at Ludlow. Since even this well is not in use, there is no ground water extraction from the basin.

Ground Water Quality. The only chemical analysis of the ground water was an approximate analysis of the water from the railroad's 1,600 foot well at Ludlow, which was made in March 1883. This analysis has several radicals recorded together so that it is impossible to determine the general character of the water. Total dissolved solids in the ground water were reported to be about 473 and 554 ppm at the 785 and 1,084 foot depths, respectively.

From the surrounding surface features of the valley, the ground water beneath Broadwell Lake would probably have a higher mineral content than the water from the higher alluvial slopes.



STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN BROADWELL VALLEY GROUND WATER BASIN

SCALE OF MILES
5 0 5

Soda Lake Valley Ground Water Basin (6-33)

Soda Lake Valley Ground Water Basin, shown on Figure 27, is an irregularly shaped northerly trending area of about 590 square miles located in the northeastern part of San Bernardino County in the Mojave River Drainage Basin (No. 19).

The northern boundary of the basin is formed by an alluvial divide. The eastern boundary of the basin is formed by the Marl and Kelso Mountains; the Bristol and Cady Mountains form the southern boundary, and the Soda and Cave Mountains are to the west.

Several hills protrude from the valley floor in the eastern part of the valley, extending 600 to 2,000 feet above the valley floor. The mountains on the eastern border reach an elevation of 4,936 feet. The valley floor slopes centripetally from the outer edges to Soda Lake, and ranges in elevation from 933 feet at the southern end to 923 feet in the north. Soda Lake, a compound type playa, covers an area of 40.7 square miles.

Geology

The mountains to the northeast and east consist of pre-Tertiary granitic and metamorphic rocks, and Quaternary volcanic rocks which have formed numerous cinder cones. Old Dad Mountain and the adjoining peaks on the southeast consist of Precambrian and Paleozoic sediments and metasediments and pre-Tertiary granitic rocks. To the south, the Bristol Mountains are composed of pre-Tertiary granitic and metamorphic rocks and the Cady Mountains largely of Tertiary and/or Quaternary volcanic rocks and sediments. These sediments also occur along western and southeastern margins of the basin.

Quaternary alluvium, exposed over most of the basin floor, is partially masked by playa and dune sand deposits. The sand dunes extend from the Mojave River Sink eastward to the Devil's Playground and then southeasterly into Kelso Valley. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 400 feet.

Water Supply

The principal source of ground water replenishment in Soda Lake Valley Ground Water Basin is percolation of flow in the Mojave River and streamflow originating in the watershed. The annual rainfall on the valley floor averages three and one-half inches. During infrequent extreme flood conditions, the Mojave River floods through Afton Canyon into the Mojave River Sink. This flood runoff may either flow toward East Cronise Lake, Soda Lake, or to both. In 1938, water overflowed from Soda Lake into Silver Lake through a wash near Baker. The only other surface flow into Soda Lake is infrequent runoff from the surrounding mountains.

The basin's major recharge areas consist of the alluvial fans that fringe the valley and the Mojave River Sink; both are rated at moderate recharge capacity. Usable ground water supplies are derived from the Recent and underlying older alluvial deposits.

The basin receives the largest quantities of subsurface inflow from Caves Canyon Valley Ground Water Basin; smaller quantities enter from the Kelso and Broadwell Valley basins. Ground water movement is generally toward Soda Lake and then northward into Silver Lake Valley. The hydraulic gradient between well 11N/8E-8N1 at Crucero, to Zzyzx Mineral Springs (12N/8E-11F1) is about eight to nine feet per mile. This gradient then flattens out to about three feet per mile from the Zzyzx Mineral Springs to a well at Baker. Water levels in wells in the Crucero area have fallen approximately 10 to 15 feet since 1919, while water levels in other parts of the valley have remained constant for this same period.

Development and Utilization. By 1914, homestead entries had been made on about 10,000 acres in the Crucero area and by 1919, several hundred acres had been cleared and about 25 wells had been dug or drilled. The expected land development did not materialize and in 1922 only two or three homesteaders had received patents on their land. During this period, small settlements were established at sidings along the Tonopah and Tidewater and the Los Angeles and Salt Lake Railroads. The latter of these railroads is now the Union Pacific line, which runs east to west through the southern part of the valley. An old railroad bed is all that remains of the Tonopah and Tidewater Railroad which ran north to south through the valley. Some agriculture was attempted, but the soil and water quality were too poor for good crop production.

Presently, Baker is the only town in the basin; its population in 1961 was about 300. There are several ranches, most of which are abandoned, scattered throughout the valley. Most of the wells in the Crucero area have been destroyed. There are less than 50 wells in the basin, the majority of which are unused. The wells that are presently in use are mainly located at Baker.

The ground water in the basin is used mostly for domestic purposes at Baker and at present, there are no irrigated crops in the valley. It is estimated that the ground water extraction for the entire valley, excluding the Zzyzx Springs, is less than 90 acre-feet per year.

Water Quality. The quality of ground water has remained constantly marginal to inferior since 1915 because of the high fluoride content and the high percentage of sodium ion. Ground water in the vicinity of the dry lake and Crucero area has a sodium chloride or sodium bicarbonate-sulfate character. The percent sodium ranges from 59 to 96 percent and averages 80 percent for the 31 ground water analyses. The fluoride ion concentration varies from 0.8 to 12.0 ppm and averages 3.2 ppm; the total dissolved solids content averages 1,510 ppm.

Ground water in the Mojave River Sink area, from Crucero to Rasor, has a total dissolved solids content of 400 to 900 ppm, but water from the north and south sides of the river channel in this area has a total dissolved solids content which ranges as high as 3,000 ppm. The well at Sands (11N/10E-29B1) produces water having a total dissolved solids content of about 250 ppm, the lowest concentration found in the basin. Limited data indicate that ground water east of Soda Lake is in the 250 to 800 ppm range; water from well 12N/8E-11F1, near the west edge of the lake, has a total dissolved solids content of about 2,000 ppm. Wells on the west side of Baker produce water which has a total solids content of about 3,000 ppm; those on the east side of town produce water with about 1,000 ppm.

The water from springs in the basin is inferior in quality and has a character generally similar to that of ground water. The total dissolved solids content averages 2,590 ppm and the fluoride content averages 10.3 ppm for the springs.

TABLE 33

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
SODA LAKE VALLEY GROUND WATER BASIN (6-33)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Marginal	Inferior	Basis for Classification: Marginal	Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	feet or cfs	Use
S.W. part of basin 12N/7E-36L1			DI	TDS, EC, SO_4, Cl	F, B, % Na		Na Cl			Unknown
11N/8E-8N1		I	D	% Na	F		Na HCO_3	2-26-54	17.51ft	Domestic
Mesquite Spring 11N/7E-25L1			DI		EC, SO_4, Cl F, B, TDS, % Na		Na Cl	2- 2-19 10-22-57	flow flow	Unknown
S.E. part of basin 11N/10E-29B1	I		D		F	11.5 ± 2.2	Na HCO_3-Cl	2- 4-44	216 ft	Domestic
Dry Lake Area 13N/8E-12H1			DI	F	EC, CL, TDS % Na	0.00 ± 1.54	Na Cl	2-18-54 10- 8-59	22.95ft 25 ft	Unknown
13N/9E-20J1			DI	SO_4, TDS	EC, Cl, % Na F		Na Cl	2-18-54 3-11-59 3- 8-61	65.82ft 65.55ft 65.53ft	Unknown
-22Z1			DI		F, % Na		Na Cl	4-15-53	65 ft	Unknown
12N/9E-4B1			DI		F, % Na	2.07 ± 1.58	Na Cl-HCO_3	10- 8-59	20 ft	Unknown
Spring 12N/8E-2D1			DI		EC, Cl, F, B, TDS, % Na SO_4		Na Cl	4- 7-55	flow	Unknown
-11F1			DI	SO_4	EC, Cl, F, B, TDS, % Na		Na Cl	12- 7-19 4- 7-55 10- 8-59	flow flow flow	Domestic

D - Domestic
I - Irrigation

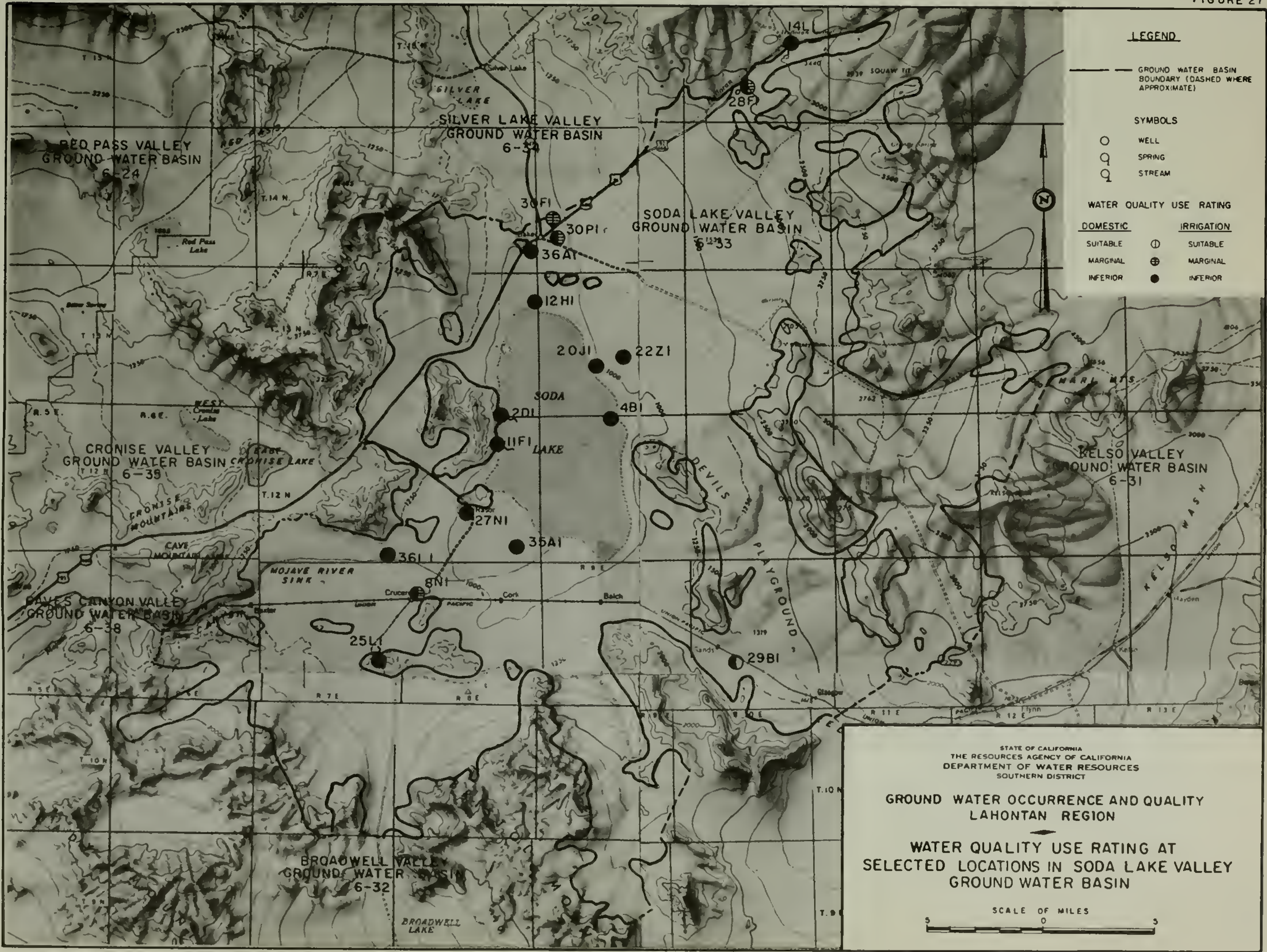
TABLE 33

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
SODA LAKE VALLEY GROUND WATER BASIN (6-33)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	feet or cfs	Use
Dry Lake 12N/8E-27N1			DI		F, % Na		Na HCO_3	12-7-19 5-26-54 1-6-60	12.6ft 15 24	Unknown
12N/8E-35A1			DI	B	F, % Na		Na HCO_3	5-26-54	6.80 ft	Unknown
Baker 14N/9E-30F1		DI		EC, % Na F, B, EC		5.6 ± 1.0 14.4 ± 0.9 1.4 ± 2.2	Na Cl-HCO_3	9-11-53 2-17-54 9-13-54	62.2 ft 64 ft 62.1 ft	Domestic
14N/8E-36A1			DI	F, % Na	EC, Cl, TDS	17.3 ± 1.9	Na Cl	10-25-61	25.3 ft	Domestic
14N/9E-30P1		I	D	EC, TDS, B, SO_4, Cl, % Na	F		Na Cl-HCO_3	2-18-54	50.42ft	Domestic
N.E. part of basin 15N/10E-28F1		I	D	NO_3, % Na	F		Na HCO_3-SO_4	5-27-55	165 ft	Domestic
Halloran Spring 15N/10E-14L1			DI	B	F, % Na		Na HCO_3-SO_4	8-23-16 10-29-17	flow flow	Unknown

D - Domestic
I - Irrigation

FIGURE 27


LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
MARGINAL
INFERIOR
SUITABLE
MARGINAL
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN SODA LAKE VALLEY
GROUND WATER BASIN
SCALE OF MILES
5
0
5
RED PASS VALLEY
GROUND WATER BASIN
6-24
SILVER LAKE VALLEY
GROUND WATER BASIN
6-34
SODA LAKE VALLEY
GROUND WATER BASIN
6-33
KELSO VALLEY
GROUND WATER BASIN
6-31
CRONISE VALLEY
GROUND WATER BASIN
6-39
CAVES CANYON VALLEY
GROUND WATER BASIN
6-38
BROADWELL VALLEY
GROUND WATER BASIN
6-32
SILVER LAKE
SODA
LAKE
DEVILS
PLAYGROUND
MOJAVE RIVER
SINK
WEST Cronise Lake
EAST CRONISE LAKE
CRONISE MOUNTAINS
CAVE MOUNTAIN
BROADWELL LAKE
Red Pass Lake
KELSO WASH
14L1
28F1
30F1
30P1
36A1
12H1
20J1
22Z1
2D1
4B1
11F1
27N1
35A1
36L1
8N1
25L1
29B1
Crucero
Cork
Baker
Kelso
Glasgow
Flynn
T.15 N
T.14 N
T.13 N
T.12 N
T.11 N
T.10 N
T.9 N
R.5 E
R.6 E
R.7 E
R.8 E
R 11 E
R 12 E
R 13 E

Silver Lake Valley Ground Water Basin (6-34)

Silver Lake Valley Ground Water Basin, shown on Figure 28, is a northerly trending irregularly shaped area of about 40 square miles, located in the north central portion of San Bernardino County, in the Mojave River Drainage Basin (No. 19).

This basin is bounded on the west by low hills that extend north from the Soda Mountains, and on the east by a series of unnamed low hills. Alluvial highs form the basin boundary on the north and south. The hills on the east and west rise about 1,500 feet above the valley floor which stands at an elevation of about 1,200 feet. The valley slopes toward Silver Lake, which includes an area of 3.2 square miles, and stands at an elevation of about 900 feet.

Geology

The hills on the west and east are composed largely of pre-Tertiary granitic and metamorphic rocks. The northern and southern limits of the basin consist of Quaternary alluvium which also covers the floor of the basin. In the northwestern part of the basin the playa deposits mask the valley fill which extends to a depth of at least 180 feet. Along the hills west of Silver Lake, there are wave-cut cliffs and terraces that are evidence of Lake Mojave which existed during the Pleistocene.

Water Supply

The principal source of ground water replenishment in the basin is percolation of streamflow originating in the watershed. Precipitation in the valley averages approximately three inches and often appears as thundershowers. During the rare floods, resulting from heavy flows in the

Mojave River, the valley has received surface inflow from Soda Lake through a wash near Baker. The only other surface inflow to the valley is the occasional runoff from the surrounding hills.

The major recharge areas for the valley are the fans of the Soda Mountains which are rated as having a moderate to high recharge capacity. Usable ground water supplies are derived from the Recent and underlying older alluvial deposits.

Subsurface inflow from the Soda Lake Ground Water Basin moves in a northerly direction toward the abandoned town of Silver Lake. The hydraulic gradient between the southern boundary near Baker and well 15N/8E-15Q1 near the northern boundary is approximately five feet per mile. Since the water table lies 50 to 60 feet below the ground surface at the north end of Silver Lake and there seems to be a continuous hydraulic gradient through the basin, there is probably a subsurface outflow from this basin into the adjoining Riggs Valley Ground Water Basin to the north.

Development and Utilization. In 1918, the Tonopah and Tidewater Railroad crossed the valley in a northerly direction; today, only the old railroad bed remains. When this railroad was active, the town of Silver Lake had a general store, and there was a population of 25 to 50 residents in the valley.

In 1950, well 15N/8E-22R1 was drilled for a small milling operation. The ore for this mill was brought in by truck from a mine in the Owlshead Mountains, northwest of the valley. This milling operation was abandoned after a few years, and presently there are fewer than 15 people living in the valley. The majority of these people live close by an electric power substation of the Los Angeles Department of Water and Power north of Silver Lake.

There have been about eight wells in the basin, but most of these have been destroyed. Presently, the only known use of the ground water is for the domestic supply at the power substation. It is estimated that the ground water extraction for the valley is less than five acre-feet per year.

Ground Water Quality. The quality of the valley's ground water is rated marginal to inferior for both domestic and irrigational uses, as shown on Table 34. High concentrations of fluoride and high percent sodium are the major causes for the inferior rating. Fluoride concentrations in the south end of the basin are probably about one ppm as indicated by wells at Baker, but fluoride concentrations are greater (two to four ppm) at the northern end of the valley. The high percent sodium also follows this pattern, being about 70 percent at Baker and about 90 percent in the north end of the valley.

The total dissolved solids content of the ground water moving into the Silver Lake basin from the Soda Lake basin is about 1,000 to 3,000 ppm. It would, therefore, be reasonable to expect ground water in the Silver Lake basin to have a total dissolved solids content of about 1,000 ppm, as is the case. The three samples from the basin range from 1,100 to 1,740 ppm total dissolved solids. Ground water in the basin is sodium chloride or sodium bicarbonate-chloride in character.

TABLE 34

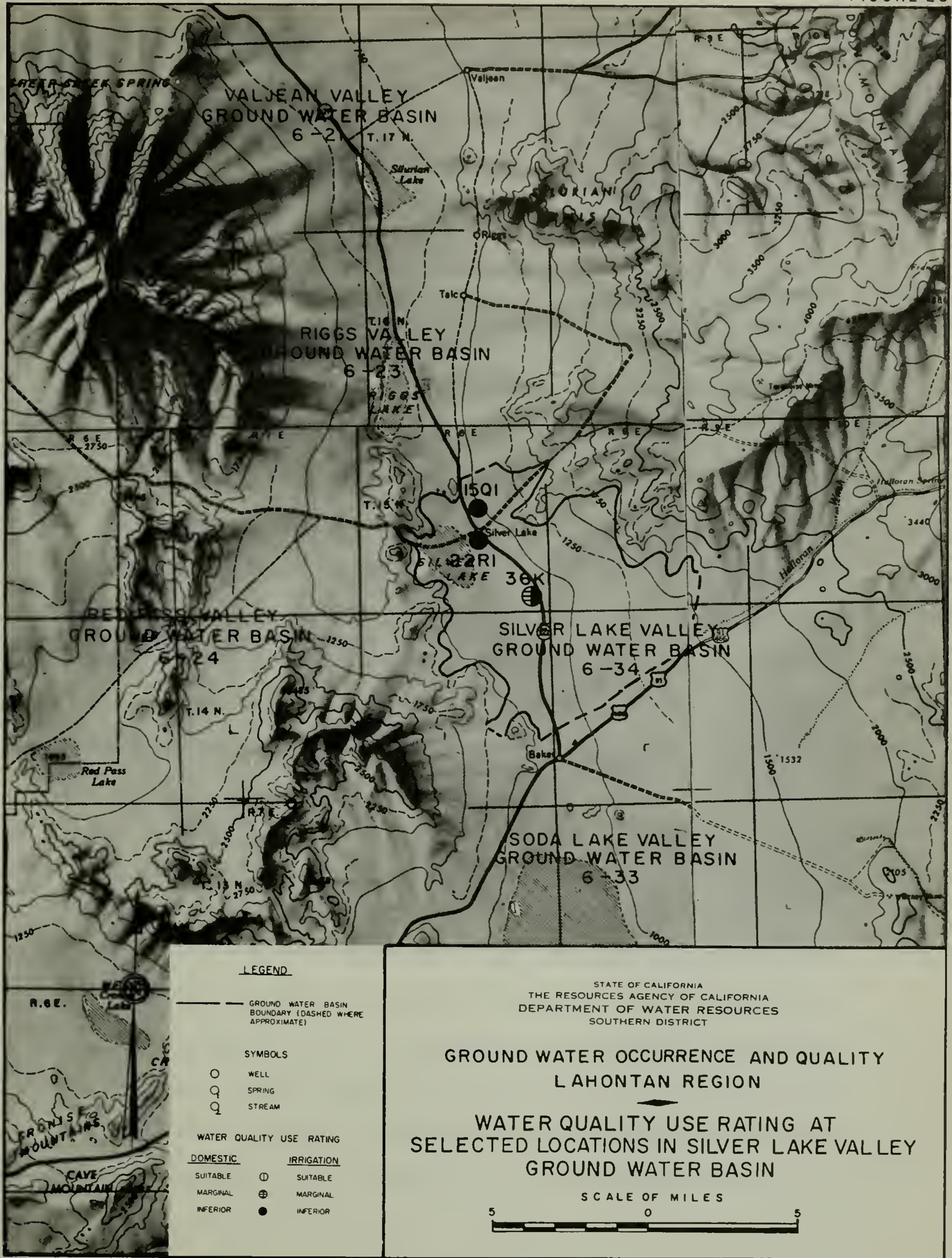
REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
SILVER LAKE VALLEY GROUND WATER BASIN (6-34)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
N.W. of Silver Lake 15N/8E-15Q1			DI	EC, B, TDS	Cl, F, % Na		Na Cl	2-19-54	138 ft	Domestic
15N/8E-22R1			DI	EC, B, TDS	F, % Na		Na HCO_3-Cl	2-18-54 10-27-54 4-25-55	55.92ft 55.98ft 56.6 ft	Unknown
S.W. of Silver Lake 15N/8E-36K1*		D	I	EC, B, TDS	% Na		Na HCO_3-Cl	2-15-53 2-18-54	25 ft 36.44ft	Unknown

*Fluoride not tested

D - Domestic
I - Irrigation

FIGURE 28


VALJEAN VALLEY
GROUND WATER BASIN
6-21
RIGGS VALLEY
GROUND WATER BASIN
6-23
SILVER LAKE VALLEY
GROUND WATER BASIN
6-34
SODA LAKE VALLEY
GROUND WATER BASIN
6-33
GROUND WATER BASIN
6-24
15Q1
22R1
36K
Valjean
Silurian Lake
Riggs
Talc
Silver Lake
Baker
Red Pass Lake
Halloran Spring
T.17 N.
T.16 N.
T.15 N.
T.14 N.
T.13 N.
R.9 E.
R.8 E.
R.7 E.
R.6 E.
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
SUITABLE
MARGINAL
MARGINAL
INFERIOR
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN SILVER LAKE VALLEY
GROUND WATER BASIN
SCALE OF MILES
5
0
5

Cronise Valley Ground Water Basin (6-35)

Cronise Valley Ground Water Basin, shown on Figure 29, is an irregularly shaped, northwesterly trending area of about 154 square miles, located in the central portion of San Bernardino County, within the Mojave River Drainage Basin (No. 19).

It is bounded on the north by the Tiefort Mountains, on the northeast and east by the Soda Mountains. The southern boundary is formed by alluvial highs lying between Cave Mountain and the eastward extension of Alvord Mountain.

The Tiefort Mountains rise to an elevation of 5,090 feet, while the other ranges are about 3,000 feet in elevation. The valley floor slopes from the Alvord Mountain extension to the Bitter Spring area and then southeasterly to West Cronise Lake. This dry lake stands at an elevation of 1,070 feet and includes an area of about 1.5 square miles. It lies about one mile northwest of East Cronise Lake, which includes an area of about two square miles. East Cronise Lake is also a dry lake; it stands at an elevation of about 1,075 feet.

Geology

The Tiefort Mountains on the north are comprised mainly of pre-Tertiary igneous and metamorphic rocks, and their extension to the east consists of Tertiary and/or Quaternary sediments. The Soda Mountains on the east are composed mainly of pre-Tertiary granitic rocks and Tertiary volcanic rocks. Alluvial highs or divides make up other portions of the basin's periphery; the most extensive alluvial separations occur between Cronise Valley and Red Pass Valley on the north and Langford Valley on the west. The basin is bordered, in part, on the south by pre-Tertiary granitic and metamorphic rocks of Cave Mountain which is associated with the adjacent Cronise Mountains to the north. The easterly extension of Alvord Mountains consists of Tertiary and/or Quaternary volcanic rocks and sediments.

Quaternary alluvium comprises the upper portion of the valley fill which extends to a depth of at least 430 feet. The two dry lakes in the valley are separated by alluvial fans which extend southeasterly from the Soda Mountains. Sand dunes also occur in the area between the two dry lakes.

Water Supply. The annual rainfall for Cronise Valley is probably less than four inches. East Cronise Lake has been flooded by the Mojave River at least three times: 1916, 1922, and 1938. Besides these rare floods, the only surface water that flows into the valley is the occasional runoff from the surrounding mountains. The alluvial fans of the Tiefort and Soda Mountains are the principal source of recharge to the alluvial materials of the basin, from which most of the wells obtain their water supply.

Subsurface inflow to the valley probably occurs from Red Pass Valley Ground Water Basin on the north, but the main source of subsurface flow into the basin is from the Soda Lake Valley basin via the Mojave River Sink. Flow in the Mojave River rises to the surface as it moves into Afton Canyon, then toward the east end of the canyon, as it approaches the Mojave River Sink, the river sinks beneath the surface. A portion of this subsurface water moves from the sink area northward through an alluvial channel into Cronise Valley.

Water levels near East Cronise Lake have dropped approximately 5 to 10 feet since the period of record began in 1932. The water levels from well 12N/6E-4G1 in the area of West Cronise Lake have remained constant since records were started in 1953. The depths to water vary from 12 to 45 feet in all the known wells in the valley.

Development and Utilization. Several attempts were made prior to 1919 to grow crops on East Cronise Lake, but were unsuccessful because of the high salt content in the soil. Between 1919 and 1922 attempts were made to impound the flood waters of the Mojave River for irrigation in the southeastern part of the valley. Because the flood flows were infrequent and deposited silts in the reservoir, the projects were never completed. In 1953, 100 acres of cotton were grown, but because only ten bales of cotton were produced the project was discontinued. The population of the valley has probably never exceeded 100 and it is now estimated to be fewer than ten.

There are approximately 13 wells in the valley; all are south of East Cronise Lake except for Bitter Spring and well 12N/6E-4G1. The majority of these wells are unused or dry. Presently, there is an attempt at developing a 40-acre tract for irrigation on East Cronise Lake. Approximately five acre-feet per year of ground water are extracted from the basin.

Water Quality. The quality of the ground water has remained inferior since the period of record was started in 1953. As shown on Table 35, fluoride, boron, and a high percent sodium are the main constituents for the ground water being classified as inferior. The general character of the subsurface inflow from the Mojave River sink determined from well 12N/7E-30J1 is sodium bicarbonate; ground water in the East Cronise Lake area has a sodium chloride character. Bitter Spring, in the central part of the basin, has a sodium sulfate character.

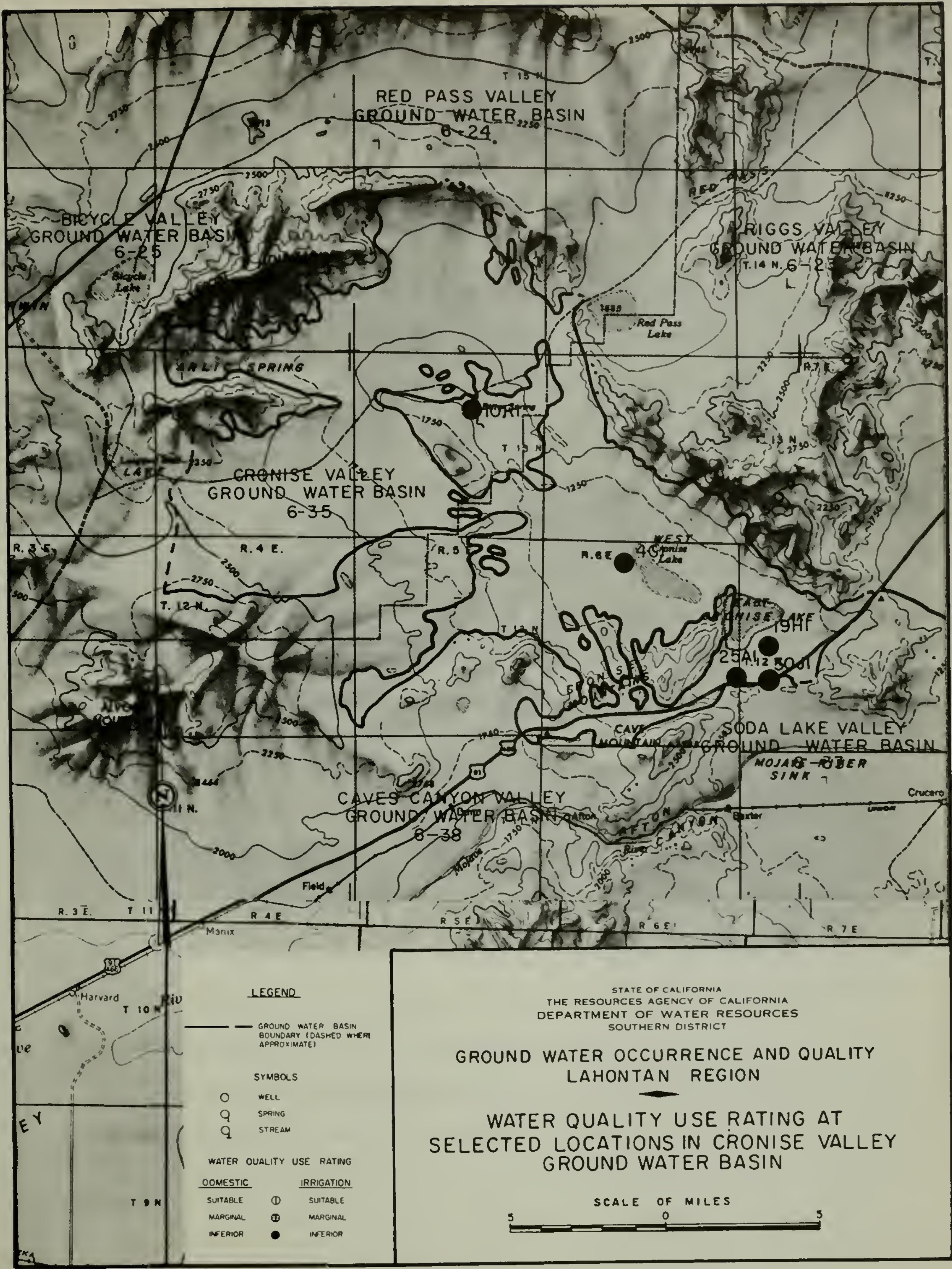
The total dissolved solids content of the ground water ranges from 510 to 2,958 ppm and averages 1,680 ppm, while the fluoride content varies from 1.7 to 6.65 ppm and averages 3.4 ppm. The average percent sodium is 91. The boron concentration ranges from 0.87 to 4.18 ppm and averages 2.5 ppm. The water from Bitter Spring has the poorest quality in the basin. The total dissolved solids content of this water is 5,027 ppm, and the sulfate content is 1,899 ppm. The poor quality of the ground water has been one of the major obstacles to development in the Cronise Valley Ground Water Basin.

TABLE 35

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
CRONISE VALLEY GROUND WATER BASIN (6-35)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
East Cronise Lake 12N/6E-25A1			DI		F, B, % Na		Na HCO_3	2-17-54 1- 6-60 7-26-60	18.9ft 24.0ft dry	Unknown
12N/7E-19H1			DI		Cl, F, % Na EC, TDS, B		Na Cl	3-20-53 5-19-53 2-17-54	25 ft 20 ft 26.33ft	Irrigation
12N/7E-30J1			DI		F, % Na		Na HCO_3	6- 8-32 2-17-54 3- 7-61	32 ft 44.42ft 48.80ft	Domestic
West Cronise Lake 12N/6E-4G1			DI		B, TDS, % Na EC, Cl, F		Na HCO_3-Cl	3- 4-53 3- 7-57 3- 7-61	25.7 ft 25.80ft 25.39ft	Unknown
Bitter Spring 13N/5E-10R1			DI		F, B, TDS, % Na, EC, SO_4, Cl		Na SO_4	2-26-17 6-17-43 3- 4-53	flow flow flow	Unknown

D - Domestic
I - Irrigation


RED PASS VALLEY
GROUND WATER BASIN
6-24
BICYCLE VALLEY
GROUND WATER BASIN
6-25
RIGGS VALLEY
GROUND WATER BASIN
6-23
Red Pass Lake
CRONISE VALLEY
GROUND WATER BASIN
6-35
10R1
4G
19H1
25A1
30J1
SODA LAKE VALLEY
GROUND WATER BASIN
MOJAVE RIVER SINK
CAVES CANYON VALLEY
GROUND WATER BASIN
6-38
AFTON CANYON
Baxter
Crucero
Field
Manix
Harvard
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
SUITABLE
MARGINAL
MARGINAL
INFERIOR
INFERIOR
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SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN CRONISE VALLEY
GROUND WATER BASIN
SCALE OF MILES
5
0
5

Langford Valley Ground Water Basin (6-36)

Langford Valley Ground Water Basin, shown on Figure 30, is an irregularly shaped, northerly trending area of about 48 square miles, located in the north central portion of San Bernardino County, in the Mojave River Drainage Basin (No. 19).

The basin is bordered on the north and northeast by the Tiefort Mountains. The eastern and southern boundaries are formed by alluvial highs extending from the Alvord Mountains which lie at the southeast corner of the basin. Northwest trending hills form the western boundary of the basin.

Maximum elevation of the valley is attained in the Tiefort Mountains which rise to 5,000 feet. The ranges to the south are at an elevation of about 3,500 feet. The valley floor slopes toward Langford Lake located at the southeast corner of the basin; this dry lake, at an elevation of 2,161 feet, includes an area of about one square mile.

Geology

The mountains on the north are composed of Tertiary volcanic rocks and sediments; the Tiefort Mountains to the northeast consist largely of pre-Tertiary metamorphic rocks. The alluvial highs to the east and south converge at Alvord Mountain which consists of Tertiary sediments and volcanic rocks. The hills on the west which extend to an alluvial high on the northwest, are composed of pre-Tertiary granitic rocks.

The Quaternary alluvium comprises the upper portion of the valley fill which extends to a depth of at least 524 feet.

Water Supply

The annual rainfall for the valley is probably less than four inches. Occasional runoff from the surrounding mountains is the only surface inflow to the valley. The major recharge areas of the valley are in the alluvial fans directly north of Camp Irwin.

Under normal conditions, ground water in the Recent and underlying older alluvium in the northern part of the basin, would move southeasterly with a hydraulic gradient of about 10 feet per mile toward Langford Lake. However, during periods of heavy pumping at Camp Irwin, the hydraulic gradient is altered locally and ground water moves toward Camp Irwin. There is no known subsurface inflow or outflow in the basin. Water levels at wells in the Camp Irwin area dropped about 11 feet between 1941 and 1959.

Development and Utilization. The Langford Well located on the western side of Langford Lake, on the road from Daggett to Death Valley, was one of the important watering places in 1904, but the well is now caved in. In 1941 the first well at the Camp Irwin military reservation was drilled; since then, six additional wells have been drilled at the main post. About three miles northwest of Camp Irwin a test well was drilled to a depth of 335 feet, but failed to yield water. Another test well (13N/3E-35B1), located south of Langford Lake encountered ground water at a depth of 86 feet.

Camp Irwin, the only populated area in the valley, is manned by approximately 1,000 military and civilian personnel. In 1941, only 33 acre-feet of ground water was used at Camp Irwin, but by 1944 this quantity had increased to 480 acre-feet because of the influx of military personnel during World War II. After World War II, ground water extractions decreased to about 55 acre-feet per year, but in 1953, production once again increased to 670 acre-feet. It is now estimated that the annual ground water extraction is about 40 to 50 acre-feet.

Ground Water Quality. As shown on Table 36, the quality of the ground water is rated as inferior because of its high percent sodium, and high fluoride and iron contents. In 1943, the iron content of water from the six Camp Irwin wells was below the United States Public Health Service Drinking Water Standards of 0.30 ppm; since then, the iron content in two of the wells has exceeded 0.30 ppm. However, this problem was solved by mixing water from all six wells to obtain an average iron content of 0.17 ppm. The fluoride content of ground water from these six wells has varied from 5.0 to 11.0 ppm, the average being about 10.0 ppm.

A defluoridization plant has been installed at Camp Irwin and according to the manufacturer it has a treatment capacity of 38,000 gallons per day. The defluoridized water is distributed through a separate system to the housing area for drinking and cooking purposes.

Ground water in this basin has a total dissolved solids content ranging from 472 to 634 ppm. The general character of the water in the Camp Irwin area is sodium sulfate-bicarbonate; ground water from the well in the Langford Lake area is sodium bicarbonate-sulfate. Camp Irwin has a sewage disposal plant located about one-half mile east of the post; this plant discharges the effluent into oxidation ponds.

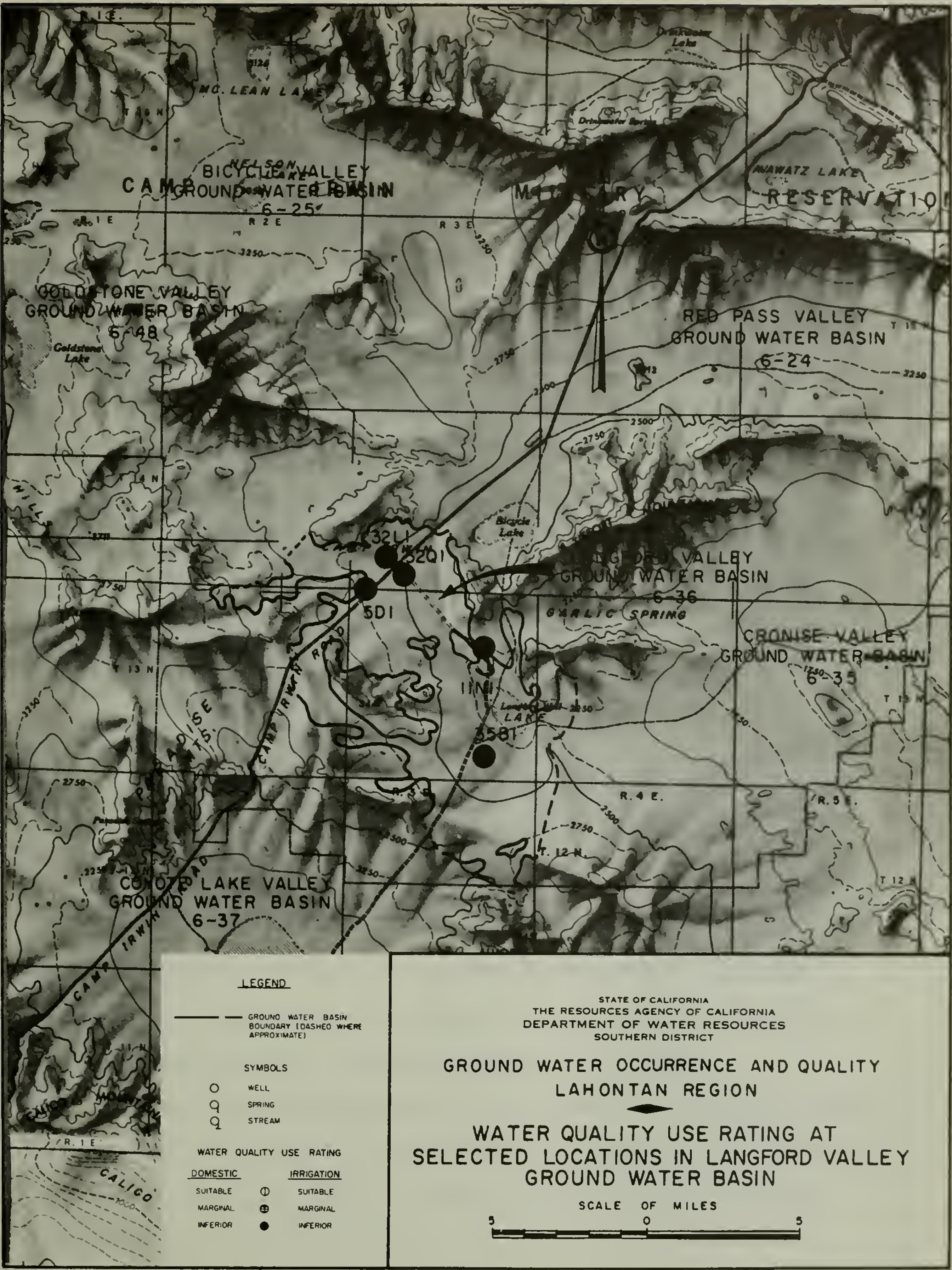
TABLE 36

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
LANGFORD VALLEY GROUND WATER BASIN (6-36)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Camp Irwin 14N/3E-32L1			DI	B	F, % Na		Na SO_4-HCO_3	11- 42 1-20-58 10-15-59	204.8 ft 210 ft 210 ft	Municipal
-32Q1			DI	B	F, % Na		Na SO_4-HCO_3	7- 48 6- 45 1-20-58	188 ft 195 ft 184.5 ft	Municipal
13N/3E- 5D1			DI		F, % Na	2.1 ± 1.0	Na SO_4-HCO_3	3- 41 9- 9-55 1-20-58	219 ft 229 ft 232 ft	Municipal
-35B1			DI		F, B % Na		Na HCO_3-SO_4	12-28-54	86 ft	Test
Garlic Spring -11N1			DI		F, % Na		Na HCO_3-SO_4	5-21-53	2 ft	Domestic

D - Domestic
I - Irrigation

FIGURE 30



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WATER QUALITY USE RATING AT SELECTED LOCATIONS IN LANGFORD VALLEY GROUND WATER BASIN

Coyote Lake Valley Ground Water Basin (6-37)

Coyote Lake Ground Water Basin, shown on Figure 31, occupies an irregularly shaped area of about 146 square miles in the north central part of San Bernardino County, within the Mojave River Drainage Area (No. 19).

The basin is bounded by the Paradise Mountains on the north, Alvord Mountain on the east, the Calico Mountains on the south, and by Lane Mountain on the west. Alluvial highs form portions of the basin boundary on the north, east, and south.

The Calico Mountains attain elevations of approximately 4,000 feet. Alvord Mountain reaches a maximum elevation of about 3,500 feet. The valley floor slopes from an elevation of 2,200 feet at its outer limits to Coyote Lake. This dry lake is at an elevation of 731 feet and includes an area of about nine square miles.

Geology

The Paradise Mountains on the north are composed of granitic rocks; Alvord Mountain to the east consists of pre-Tertiary granitic and metamorphic rocks. The southeastern boundary is an alluvial high between Alvord Mountain and the Calico Mountains. The Calico Mountains consist of Tertiary volcanic and undifferentiated older metavolcanic rocks. Lane Mountain, one of a group of mountains on the western edge of the basin, consists of undifferentiated igneous rocks.

The Quaternary alluvium is exposed over much of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 584 feet. Tertiary and/or Quaternary sediments crop out in the northeast part of the basin south of the Coyote Lake fault. A pressure area exists in the vicinity of Coyote Lake, a dry type of playa.

Water Supply

The annual rainfall for the valley is probably less than four inches and the only surface flow is the occasional runoff from surrounding mountains. The valley's main recharge areas are the alluvial fans in the vicinity of Lane Mountain, Paradise Mountains, and the Calico Mountains. The recharge capacity of these fans is rated moderate to high. Ground water which is stored in the Recent and underlying older alluvial deposits moves toward Coyote Lake from all directions at a gradient of 4 to 9 feet per mile. A confining stratum on the north and west sides of the lakebed causes a pressure area which has produced artesian flows in wells drilled near the lake. Considerably higher water table elevations in the adjoining Superior Valley and Langford Valley Ground Water Basins may cause subsurface inflow from these basins to Coyote Lake Valley basin. There also appears to be some mixing of ground water between Coyote Lake Valley basin and Lower Mojave River Valley basin along their common boundary, due to pumping depressions in this area. The water table elevations in Coyote Lake Valley basin have remained fairly constant since 1917.

There are a number of springs in the Paradise Mountains which are significant because the water from them has a higher temperature than any other known springs in the Mojave Desert. Water temperatures at these springs, known as the Paradise Springs, vary from a maximum of 106.5° F. to approximately 82° F. for some of the smaller seeps.

Development and Utilization. The valley has experienced very little development. Some mining has taken place, and a few homesteaders have settled in the valley. Paradise Mine, which is southwest of Paradise Springs (12N/2E-7P1), has been worked some in the past with water being piped to the mine from the nearby springs. There are presently about 25 wells scattered throughout the basin, most of which are abandoned.

The major development in the valley today is the irrigated alfalfa on the southeast edge of the basin. Actually, the center of this irrigated area is in the Lower Mojave River Valley Ground Water Basin but the area extends into the southeastern edge of Coyote Lake Valley basin. About 125 acres of alfalfa were noted on the Coyote Lake side in 1961. This amount of alfalfa would require about 800 acre-feet of water per annum. However, the major portion of the water used for irrigation of this alfalfa is derived from the Lower Mojave basin. The extractions from Coyote Lake basin are less than 800 acre-feet per annum.

Water Quality. Ground water in this valley is mostly of inferior quality, as shown on Table 37. The principal constituents which cause this rating of inferior are fluoride and percent sodium. The fluoride concentration ranges from 1.5 to 18.0 ppm, and averages 6.4 ppm; the percent sodium varies from 74 to 99 percent, and averages 90 percent.

The total dissolved solids content of the ground water in the north and west areas of the basin ranges from 620 to 914 ppm. Total dissolved solids content increases toward the south and east sides of Coyote Lake, where concentrations are about 2,000 ppm. Ground water obtained near the Coyote-Lower Mojave basin boundary has a total dissolved solids content in the 300 to 500 ppm range indicating that this water probably is coming from the Mojave River area.

Ground water in the basin is predominantly sodium sulfate in character but trends more toward a sodium bicarbonate water (which is the same character as water in the Lower Mojave basin) near the Coyote-Lower Mojave basin boundary. The sodium ion is the dominant cation in these waters; sulfate. chloride, and bicarbonate are predominant anions. The four radioassays made on the ground water of the valley show the radioactivity of the water ranges from -0.4 to 18.0 pc/l.

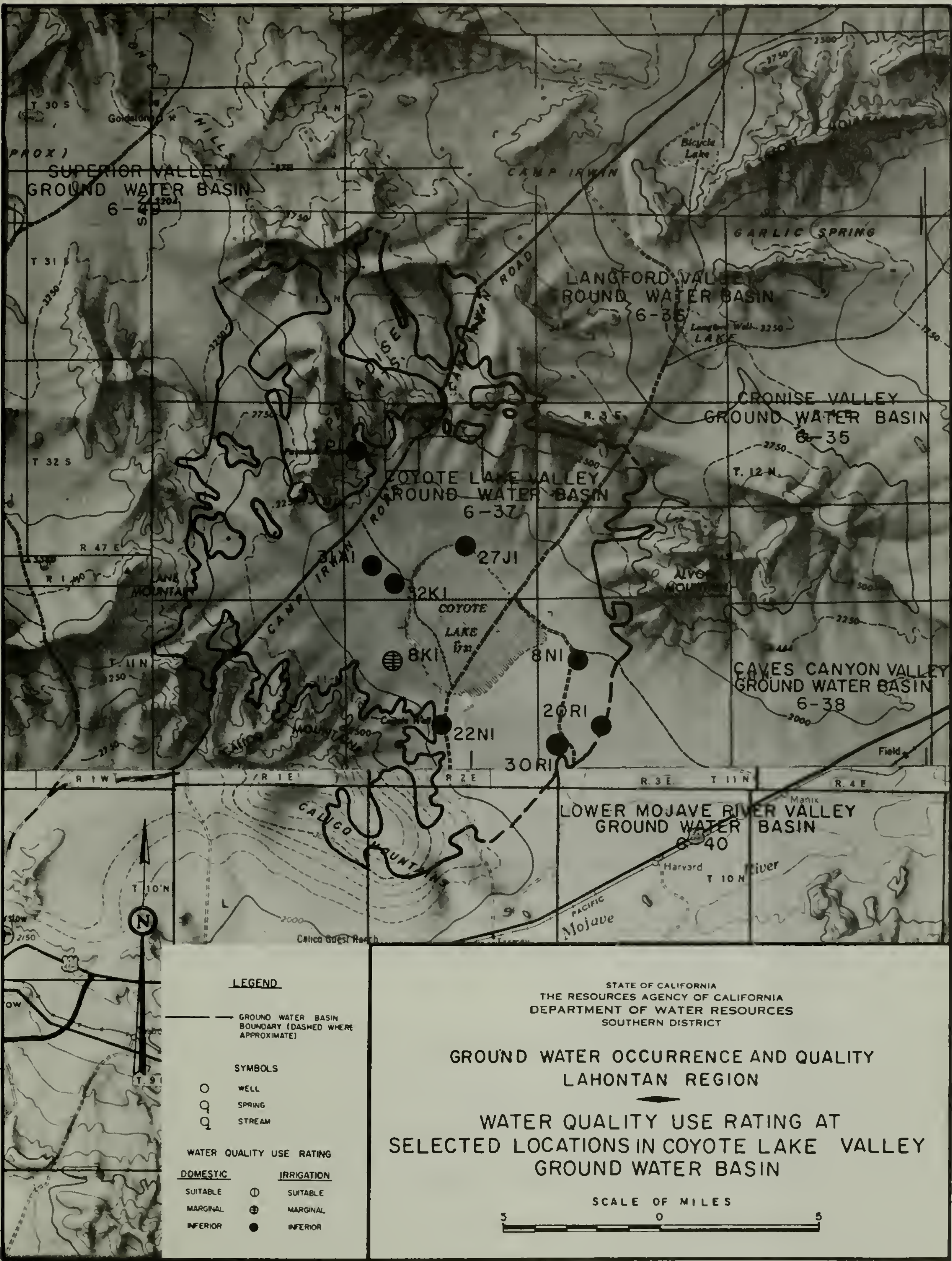
TABLE 37

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

COYOTE LAKE VALLEY GROUND WATER BASIN (6-37)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	feet or cfs	Use
SW of Dry Lake 11N/2E-8K1		DI		% Na EC, SO_4, TDS		2.8 ± 1.4	Na Cl-SO_4	2-12-18 3-10-58 3- 7-61	3.8 ft flow flow	Domestic
11N/2E-22N1			DI	EC, TDS	% Na SO_4, F, B	2.3 ± 1.4	Na SO_4	9- 6-17 7-14-32 3- 7-61	14.9 ft 14.0 ft 10.20ft	Unknown
SE of Dry Lake 11N/3E-8N1			DI		F, TDS, % Na EC, SO_4, Cl	-0.4 ± 1.4	Na Cl-SO_4	7-21-41 3-10-58 3- 6-61	3.8 ft 3.70ft 4.27ft	Unknown
11N/3E-20R1			DI		F, % Na		Na HCO_3	2-17-53 2-16-54	47.8 ft 44.88ft	Stock
11N/3E-30R1			DI		B, F, % Na		Na Cl-HCO_3			
Paradise Spring 12N/2E-7P1			DI		F, % Na		Na SO_4	2-12-18 2- 1-53	flow flow	Unknown
NW of Dry Lake 12N/2E-27J1			DI	SO_4, B	F, % Na		Na SO_4-HCO_3	2-17-53 2-16-54	flow flow	Unknown
12N/2E-31A1			DI	SO_4, B	F, % Na		Na SO_4	1- 6-55 3-10-58 3- 7-61	56 ft 55.87ft 55.96ft	Test
12E/2E-32K1			DI		F, % Na	8.2 ± 1.3	Na SO_4-Cl	7-19-41 2-11-51 3- 7-61	flow flow flow	Domestic

D - Domestic
I - Irrigation



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WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN COYOTE LAKE VALLEY
GROUND WATER BASIN

SCALE OF MILES
5 0 5

Caves Canyon Valley Ground Water Basin (6-38)

Caves Canyon Valley Ground Water Basin, shown on Figure 32, is an irregularly shaped northeasterly trending area of about 101 square miles, located in the central part of San Bernardino County, within the Mojave River Drainage Basin (No. 19).

The basin is bounded on the north by a group of low hills which extend in an easterly direction from Alvord Mountain, and on the south by the Cronise, Cave and Cady Mountains. An alluvial divide between the Lower Mojave River Valley and Caves Canyon Valley forms the western boundary.

The elevation of the bordering mountains ranges from 2,500 to 3,500 feet. The floor of the valley ranges from 2,000 feet at the outer limits to 1,400 feet along the Mojave River in Afton Canyon. A small playa whose surface stands at an elevation of 1,875 feet is located in the northeastern part of the basin.

Geology

The hills to the north, which extend easterly from Alvord Mountain to the Cronise and Cave Mountains, are composed of Tertiary volcanic rocks and sediments, and pre-Tertiary metamorphic and granitic rocks. Similar type rocks and Triassic metavolcanic rocks occur along the eastern edge of the basin. The Cady Mountains consist mainly of Tertiary volcanic rocks and sediments.

Alluvial fans from the surrounding highlands slope toward the Mojave River. Tertiary and/or Quaternary sediments occur along the flanks of the Cady Mountains and bordering hills to the north. Pleistocene lake deposits, occurring in the northeastern part of the basin, represent deposits of the ancient Lake Manix. Quaternary alluvium is exposed over much of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 220 feet.

Water Supply

Annual rainfall in the basin is about four inches; surface flow in the basin is limited to the rare Mojave River floods and to occasional runoff from the surrounding mountains. Alluvial fans from the Alvord, Cave, and Cady Mountains are the basin's major recharge areas. The capacity for these areas has been rated moderate to high.

Ground water in the Recent and underlying older alluvial deposits is recharged by inflow from the Lower Mojave River basin. The direction of this inflow generally follows the bed of the Mojave River. Underflow of the Mojave River Channel rises to the surface before it enters Afton Canyon; it flows through the canyon on the surface, but sinks underground again at the east end of the canyon.

Water levels of the wells in the basin have dropped about 15 to 20 feet since the period of record beginning in 1950.

Development and Utilization. Presently, there are about 50 people in the valley most of whom are employed at railroad sidings of the Southern Pacific Railroad; the remaining few live near Highway 91-466 which traverses the basin area.

The five known wells in the valley are located along the railroad and are used for domestic purposes. The estimated ground water extraction for the basin is about 10 acre-feet per year.

Water Quality. The water quality in the basin has remained suitable to marginal for domestic purposes, as shown on Table 38. High percent sodium has caused the ground water to remain inferior for irrigation uses. As shown by the table, the general character of the ground water varies.

The percent sodium averages 93 percent; all the analyses have been 90 percent or higher. Total dissolved solids content ranges from 622 to 1,272 ppm, and averages 904 ppm; the boron content averages 1.6 ppm. Water from well 11N/5E-11N1 has a sulfate content of 518 ppm, which renders it inferior for domestic use.

Subsurface flow of the Mojave River rises to the surface in T10N/R3E (SE 1/4) but returns to underground flow before entering Caves Canyon basin. This brief exposure to the surface evaporation, combined with other subsurface effects, causes the percent sodium in the water to increase, resulting in a change from a suitable to an inferior rating of the water quality. This change is indicated by analyses of water from two wells, shown on Figure 32, 10N/3E-23H1 and 10N/4E-19K1, and tabulated on Table 38. This concentration of salts in the ground water from surface exposure can also be seen when the subsurface flow of the Mojave River is again forced to the surface just before entering Afton Canyon. At the point of emergence the total dissolved solids content was 916 ppm; 1-1/2 miles downstream it increases to 1,461 ppm. All the other constituents, except the nitrates, also increased between these two stations.

TABLE 38

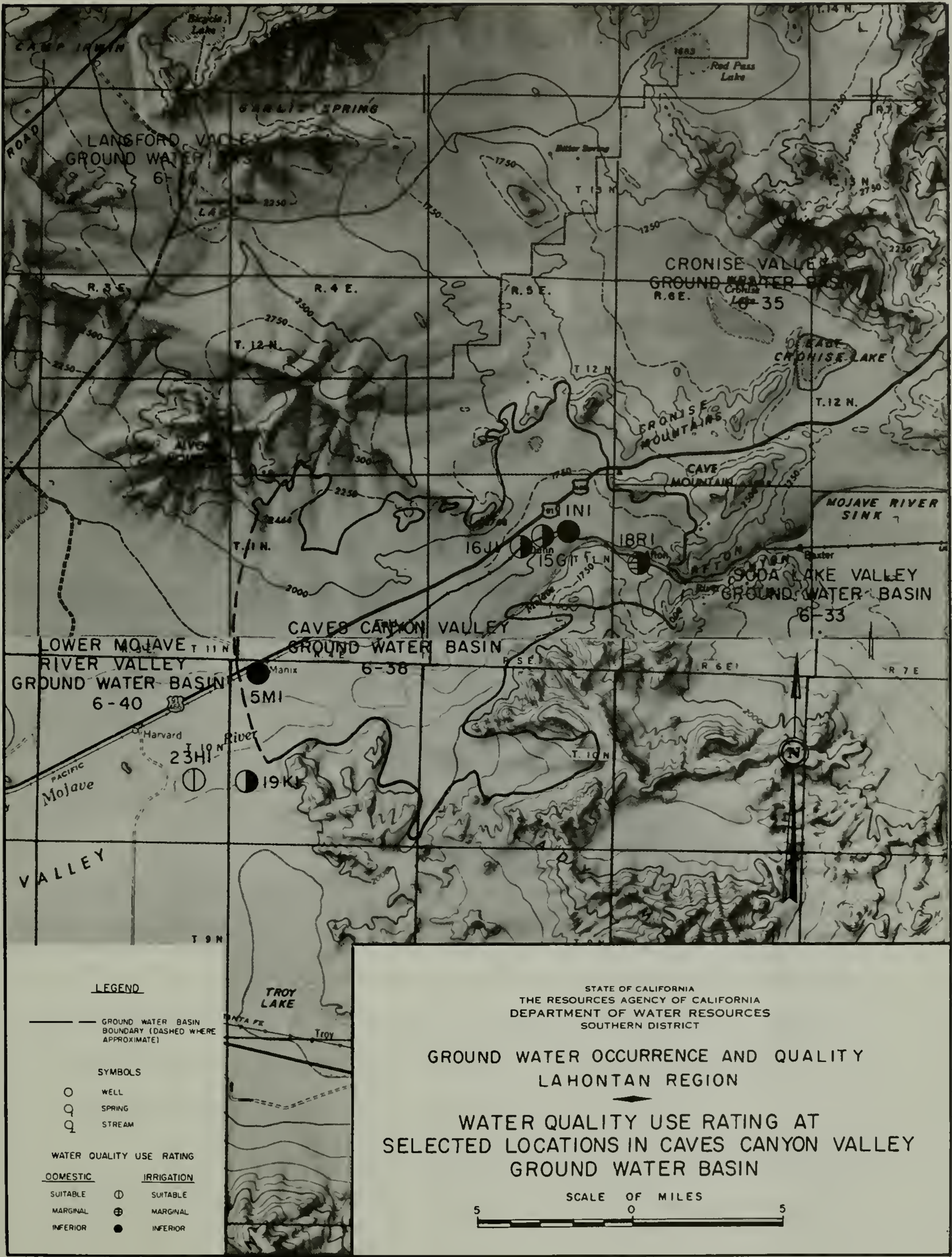
REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

CAVES CANYON VALLEY GROUND WATER BASIN (6-38)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
West of the Basin 10N/3E-23H1	DI						Na HCO_3			Irrigation
10N/4E-19K1	D		I		% Na		Na HCO_3-Cl	10- 8-59	flow	Domestic
Western part of Basin 10N/4E-5M1			DI		F, B, % Na	4.12 ± 1.89	Na HCO_3	3-13-54	93 ft	Domestic
East part of Basin 11N/5E-16J1	D		I		% Na	4.9 ± 0.7	Na HCO_3-Cl	11- 1-50 12-15-55 10-26-61	179.0ft 189.45ft 196.9ft	Domestic
-15G1	D		I		% Na	4.5 ± 0.7	Na Cl-SO_4	11-17-53	109.0ft	Domestic
-11N1			DI	EC, TDS	SO_4, % Na	4.3 ± 0.9	Na SO_4	10-24-61	150.3ft	Domestic
11N/6E-18R1		D	I	EC, F, B, TDS	% Na	3.3 ± 0.9	Na Cl-HCO_3			Domestic

D - Domestic
I - Irrigation

FIGURE 32



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WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN CAVES CANYON VALLEY
GROUND WATER BASIN

Troy Valley Ground Water Basin (6-39)

Troy Valley Ground Water Basin, shown on Figure 33, is an irregularly shaped northwesterly trending area of about 133 square miles, located near the central portion of San Bernardino County, within the Mojave River Drainage Area (No. 19).

The basin is bounded on the north and northeast by the Cady Mountains, on the east by the Mount Pisgah lava flow, on the south and southeast by the Newberry and Rodman Mountains, and on the northwest by an alluvial high which extends from the Newberry Mountains to the Cady Mountains.

Elevation of the valley floor ranges from 3,000 feet near the southern limits to 1,774 feet at Troy Lake, 5.3 square miles in extent. Maximum elevations of the surrounding mountains are attained in the Cady and Rodman Mountains which rise to heights of 4,627 feet and 6,010 feet, respectively.

Geology

The Cady Mountains to the north and northeast are composed of Tertiary volcanic rocks and sediments. The Mount Pisgah lava flow to the east is an extensive volcanic feature which also nearly divides the basin in two. This flow of Recent age is underlain by older alluvial deposits. The Rodman Mountains on the south are composed predominantly of Tertiary sediments and pre-Tertiary granitic rocks. The Newberry Mountains to the southwest consist of Tertiary volcanic rocks and sediments.

The Quaternary alluvium is exposed over much of the basin floor, comprising the upper portion of the valley fill which extends to a depth of at least 400 feet. A pressure area exists in the vicinity of Troy Lake, a moist, clay encrusted type of playa. The southeasterly extension of the Calico fault acts as an obstruction to ground water movement.

Water Supply

The principal source of ground water replenishment in the Troy Valley Ground Water Basin is percolation of streamflow originating in the Newberry and Rodman Mountains; these mountainous areas receive approximately eight inches of rainfall annually. The valley floor receives only about four inches of rainfall annually. Fans emanating from the Rodman, Newberry, and Cady Mountains are the recharge areas and are rated as moderately to highly permeable. Ground water in the Recent and underlying older alluvial deposits moves toward Troy Lake at a gradient of about 5 to 20 feet per mile; there appears to be a subsurface outflow from the northwest corner of the basin to the adjoining Lower Mojave River Ground Water Basin. There may also be subsurface inflow to Troy basin from Lavic Valley on the southeast. The water table under Lavic Lake is about 80 feet higher than the water table under Troy Lake.

There is some movement of ground water from Lower Mojave River Ground Water Basin towards the Troy Valley basin where it apparently intermingles with ground water in this basin. The water table gradient is quite flat in this area and pumping depressions could easily affect movement.

Depth to ground water at Troy Lake ranges from about 20 feet below the surface to flowing conditions. Ground water is found at increasingly greater depths south and east of the dry lake.

Development and Utilization. Relatively few attempts have been made to develop Troy basin and less than 50 persons have been known to settle in the area. Due to the occurrence of ground water at shallow depths, the western area of the basin has experienced the most development.

In 1961, approximately 120 acres of alfalfa were being irrigated in this western area. More acres have been planted and irrigated in the past, but many attempts at development of irrigated agriculture in this area have failed due to poor quality water and alkali soil conditions. Ground water extractions are estimated to be 800 acre-feet per year.

Water Quality. Ground water in the basin is generally marginal or inferior in quality, as shown on Table 39. Some suitable waters are found at the higher elevations particularly southeast of Troy Lake, but at the lower elevations near the dry lake only inferior waters are found. Marginal and inferior waters occur west of Troy Lake near the basin boundary. Ground water in this area is partially affected by underflow from the Lower Mojave River Basin mingling with Troy Valley basin ground waters.

The total dissolved solids content of the ground water varies from 278 to 3,313 ppm. The higher concentrations are found at the lower elevations near Troy Lake while lower concentrations, generally ranging between 400 and 600 ppm, are found to the west and south of the lake bed. The character of most well waters in Troy Valley basin is sodium bicarbonate; however, calcium, chloride, and sulfate also appear as prominent ions in several areas.

It is noteworthy that inferior waters appear in wells that are less than 100 feet deep. This is especially noticeable in well 9N/3E-26J3 which is approximately 100 feet from well 9N/3E-26J2. Well 9N/3E-26J2 is

255 feet deep and produces water with 988 ppm total dissolved solids; well 9N/3E-26J3 is 85 feet deep and produces water with 6,492 ppm total dissolved solids.

The main constituents which affect the quality of water in the basin are fluoride, boron, and percent sodium. Fluoride concentrations west of the dry lake are generally in the one to two ppm range while those east of the lake are in the 4 to 11 ppm range. Concentrations of boron range as high as 9.5 ppm (well 8N/3E-2R1) and percent sodium is as high as 98 (well 9N/4E-28H1). The lesser amounts of boron and percent sodium are generally found west of the lake, however, high concentrations are also found in this area.

TABLE 39

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
TROY VALLEY GROUND WATER BASIN (6-39)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Marginal	Inferior	Basis for Classification: Marginal	Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	feet or cfs	Use
8N/3E-2R1			DI		B, F, TDS, EC, Cl, SO_4		Ca Cl	10-3-58	30 ft	Unknown
8N/4E-7G1		D	I	F	% Na		Na HCO_3	1-21-55	12 ft	Unknown
-8C1			DI		F, % Na	11 $\pm$ 1.9	Na HCO_3	7-20-54	7 ft	Domestic
-12M1			DI	EC, SO_4, TDS	F, B, % Na	0.8 $\pm$ 1	Na SO_4-Cl	10-16-56	32 ft	Domestic
-18F1		D	I	B, F	% Na		Na HCO_3-SO_4	6-6-57	47 ft	Unknown
-26R1	DI						Na HCO_3-Cl	7-20-54	28 ft	Unknown
8N/5E-12Z1			DI	EC, TDS	SO_4, B, % Na		Na SO_4			Stock
-16Z1	DI						Na HCO_3			Unknown
9N/3E-13B1	DI					9.6 $\pm$ 1.9	Na HCO_3-Cl			Irrigation
-26J2	D	I		EC, B			Na-Ca Cl	7-20-61	36 ft	Irrigation

D - Domestic
I - Irrigation

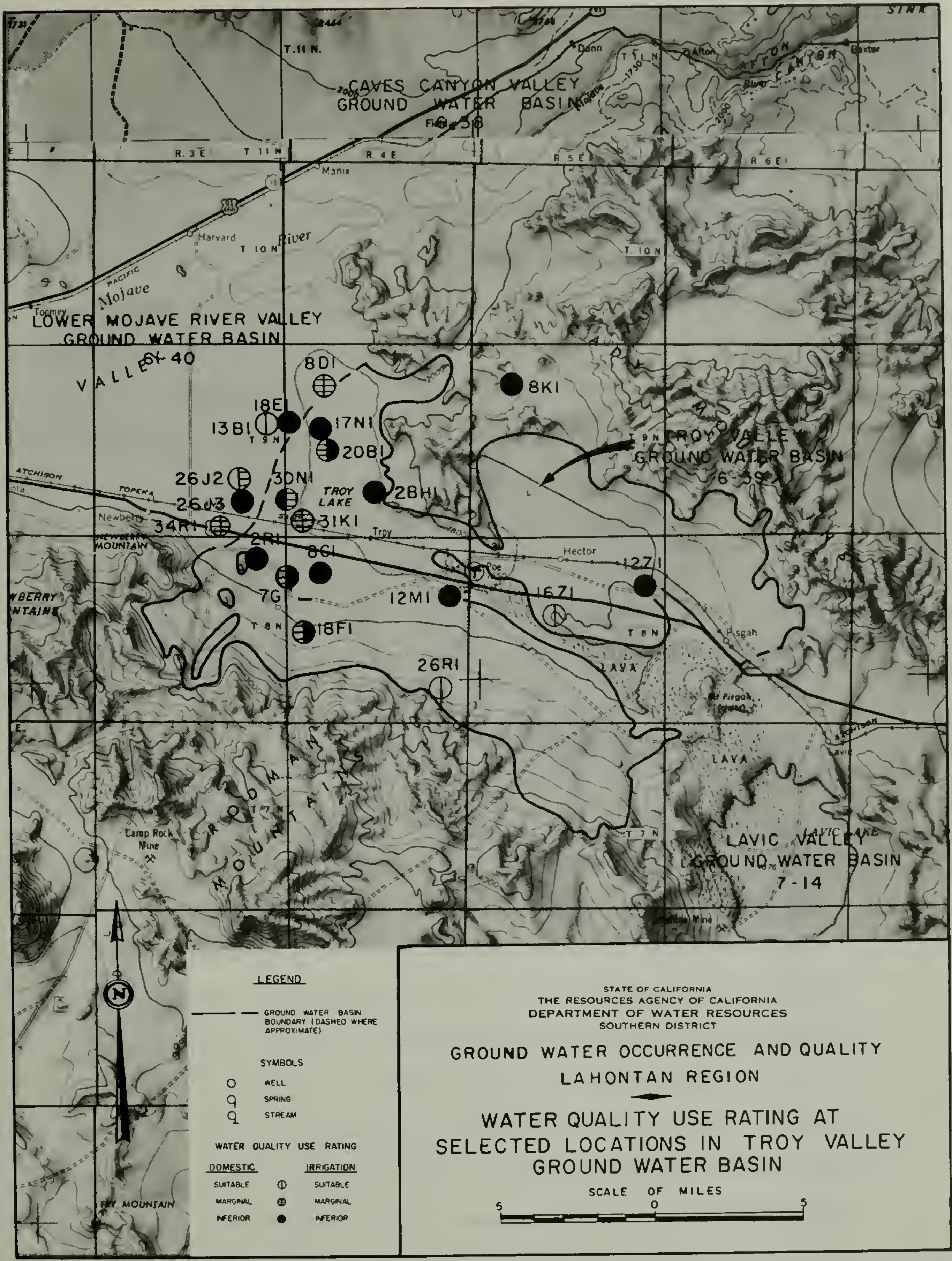
TABLE 39

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

TROY VALLEY GROUND WATER BASIN (6-39)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
9N/3E-26J3			DI	F	EC, TDS, B, Cl, SO_4		Ca Cl	7-20-61	36 ft.	Domestic
-34R1		DI		F, % Na			Na, HCO_3-Cl	3-13-54	26.4ft	Domestic
9N/4E-8D1		DI		F, % Na			Na Cl	4-10-57	21 ft	Irrigation
-17N1			DI		B, EC, SO_4, Cl, TDS		Ca-Na SO_4			Unknown
-18E1			DI	EC, B	SO_4, Cl, TDS		Ca-Na Cl	8-3-54	28 ft.	Unknown
-20B1		D	I	F, B	% Na		Na HCO_3	6-30-59	11 ft	Unknown
-28H1			DI		% Na, B, F		Na HCO_3	5-6-53	5.4 ft	Stock
-30N1		I	D	% Na	F		Na HCO_3-Cl			Unknown
-31K1		DI		% Na, F			Na HCO_3	1930 1940 1950 1960	13 ft 13 ft 13 ft 16 ft	Domestic
9N/5E-8K1			DI	TDS, SO_4, EC	% Na, B, F		Na Cl-SO_4	5-6-53	175+ft	Stock

D - Domestic
I - Irrigation



STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN TROY VALLEY
GROUND WATER BASIN

SCALE OF MILES
5 0 5

Lower Mojave River Valley Ground Water Basin (6-40)

Lower Mojave River Valley Ground Water Basin, as shown on Figure 34, is an irregularly shaped easterly trending area of about 307 square miles. The basin is located in San Bernardino County, in the south central portion of the Lahontan Region, within the Mojave River Drainage Basin (No. 19). The Mojave River, flowing from the west to the east, divides the basin into two segments.

The basin is bordered on the north by the Calico and Alvord Mountains, on the east by the Cady Mountains, and on the south by the Newberry Mountains. Alluvial divides on the east and west and an alluvial high on the north also form portions of the basin boundary.

The valley floor ranges in elevation from about 2,100 feet at Barstow on the west, to 1,760 feet to the east where the Mojave River leaves the basin. The surrounding mountains rise to elevations of about 4,000 feet.

Calico Lake, which includes an area of about two square miles, is located just north of the town of Yermo.

Geology

To the north, Tertiary volcanic rocks and sediments occur in the Calico Mountains, and in Alvord Mountain which also consists of pre-Tertiary granitic and metamorphic rocks. The Cady Mountains to the east consist of Tertiary-Quaternary volcanic and pre-Tertiary metamorphic rocks. The Newberry Mountains to the south consist of Tertiary volcanic rocks and sediments, and pre-Tertiary granitic and metamorphic rocks. Northwest of Barstow, the hills consist of Tertiary volcanic rocks, pre-Tertiary metamorphic rocks, and Precambrian and Paleozoic sediments and metasediments.

The alluvial fill extends to a depth of at least 600 feet. The Quaternary alluvium, which fills the channel of the Mojave River, is the major water-bearing material in the basin. In the vicinity of Barstow, the Recent alluvium extends to a depth of about 200 feet. Calico Lake, a dry type of playa, occurs south of the southeasterly trending Calico fault. This fault acts as a barrier to the movement of ground water.

Water Supply

Direct precipitation recorded at Barstow has averaged 4.3 inches annually for 50 years but the amount decreases to approximately 3 inches annually on the valley floor at the east end of the basin. More than 75 percent of the rainfall occurs during the months of November through April, but there are wide variations of intensity. Practically no runoff occurs on the valley floor due to the dry, flat conditions. In contrast, runoff from the Newberry and Ord Mountains is generally derived from flash floods.

Precipitation on the San Bernardino and San Gabriel Mountains provides underground and surface water flows through the Upper and Middle Mojave River Valley basin. The quantity of water moving into the basin as surface flow through the narrows at Barstow averaged about 20,000 acre-feet annually for the period 1935 to 1961. Great contrasts in surface flow characteristics are evident here. During a flood in March 1938, surface flow reached and partially filled Silver Lake, nearly 50 miles downstream from the Lower Mojave River Valley Ground Water Basin. On the other hand, about half of the 25-year period of record for this basin indicates an absence of surface flow in the Mojave River.

Springs supply a limited quantity of ground water in the basin, but most of the ground water is derived from the Recent and underlying older alluvial deposits. The most prominent springs are the Newberry Springs (9N/3E-32X), Cady Springs (9N/2E-3X), and Old Camp Cady Springs (10N/4E-30X).

Recharge of ground water in the basin is primarily from the Mojave River at Barstow where the average underflow is estimated to be 8,000 to 10,000 acre-feet per year. Movement of ground water in the Mojave River between Barstow and Daggett, a distance of about 10 miles, is initially confined to the narrows, where an underflow at a uniform gradient of 20 and 21 feet per mile existed in 1930 and 1960, as shown on Diagram 6. In the area from Daggett to the Forks-of-the-Road fault, the hydraulic gradient gradually flattens out and ground water spreads laterally; the water table in this area gradually approaches ground surface as it moves downstream toward the Forks-of-the-Road fault. Downstream of this fault, water levels usually fall about 40 feet. From here to the Cady Mountains, water levels fall an average of 21 feet per mile, but at the lower end of the basin the water table again approaches the surface.

South of the Mojave River, on the alluvial fan between Daggett and Troy Lake, the ground water gradient is one of the flattest found in the basin, averaging about eight feet per mile. North of the river on the alluvial fan, from the Yermo area to the Forks-in-the-Road fault, a ground water gradient similar to that in the Daggett-Troy Lake area is also found. East of the fault, the water table decreases an average of 14 feet per mile to Harvard and then levels off toward Manix. The ground water movement continues to the east and there is underflow to Caves Canyon basin.

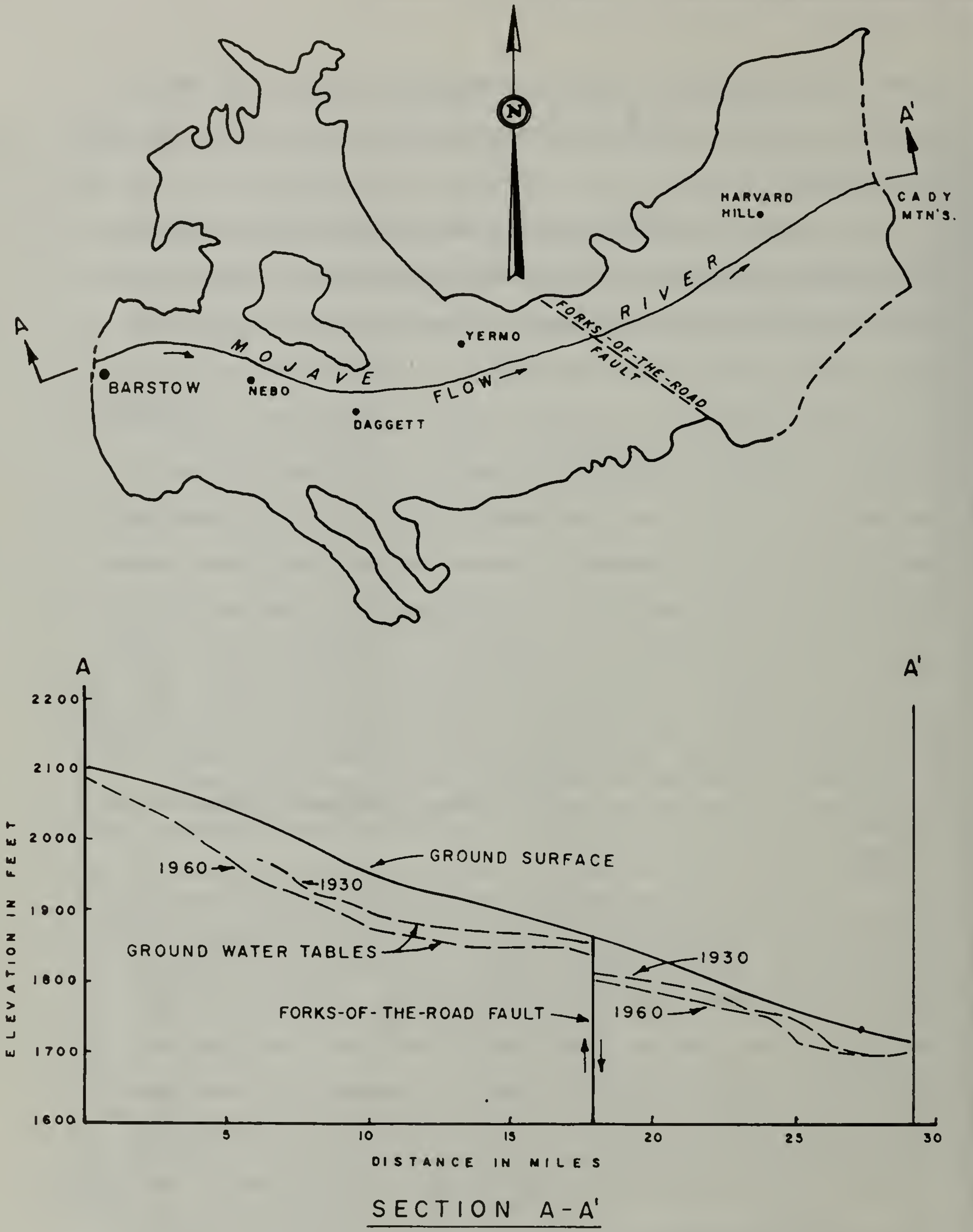


DIAGRAM 6. SECTION THROUGH GROUND WATER TABLE ALONG MOJAVE RIVER IN LOWER MOJAVE RIVER VALLEY

The ground water table in the vicinity of Barstow has remained quite constant; however, levels are lowered in dry periods and are raised during wet periods. Water levels have decreased as much as 20 feet in the Daggett area; between 1920 and 1960 levels decreased about 30 feet in the vicinity of Yermo. In the area from Daggett to the Forks-of-the-Road fault the heavy extractions have caused water levels to decline 10 to 25 feet between 1930 and 1960. Downstream from the fault, the depth to water has increased from a few feet to as much as 30 feet for the same period.

Development and Utilization. The area of the Lower Mojave River Valley Ground Water Basin has been the hub of economic activity in the Mojave River area with relatively shallow wells supplying the needed water. The population growth pattern has fluctuated from at least 5,000 in the 1880's to 2,000 in the early 1900's and eventually to over 30,000 by 1960. Barstow has evolved as the center of commerce primarily as a result of operation and maintenance facilities established by the Union Pacific and the Atchison, Topeka and Santa Fe Railroads. Barstow, Yermo, and Daggett have populations of 12,000, 700 and 500, respectively. The remaining 17,000 inhabit the farm lands dotting the alluvial plain.

The greatest number of wells are found in the Mojave River bottomlands from Barstow to the Cady Mountains and on the triangular plain south of the river.

In the first days of irrigated agricultural developments, ambitious projects, such as the "Daggett Ditch" and the Yermo Mutual Water Company Diversion were conceived. The "Daggett Ditch" was intended to utilize impounded Mojave River waters to generate electrical power for mining at Calico and provide irrigation waters for lands near Minneola.

The Yermo Mutual Water Company Diversion intended to provide waters for irrigated agriculture.

Irrigated agricultural acreage has increased from 750 acres to about 10,000 acres between 1919 and 1956. The most important crop is alfalfa even though yields have averaged somewhat lower than in Antelope Valley.

Military installations provide the largest single source of employment. The Marine Corps Supply Center at Nebo, Yermo, and Daggett is the headquarters for supply of materials to all Marine Corps units west of the Mississippi River. It employs 2,300 civilians and between 1,500 and 1,700 military personnel. Water is furnished by wells at each of the three locations. Camp Irwin, located 35 miles north of Barstow (outside of the basin) employs 360 civilians from the Barstow area and about 600 military personnel. Industrial activity, except for 1,300 employees at the Santa Fe Railroad Diesel Repair Shops, does not appreciably affect utilization of ground water.

It is estimated that ground water extractions have ranged between 60,000 and 75,000 acre-feet a year, between 1956 and 1960. Overdraft does not appear to exist at present.

Water Quality. Ground water in the Lower Mojave River Valley Ground Water Basin has been of variable quality during the past 40 years. The total dissolved solids content of the ground water in the basin is generally between 250 and 600 ppm but there are areas where concentrations of more than 1,000 ppm are found. As shown on Table 40, ground water is generally of suitable quality on the valley floor adjacent to the Mojave

River, but areas containing ground water of marginal or inferior quality are found close to the basin boundary.

Data indicate that six areas contain ground water of marginal and inferior quality, due to excessive boron and fluoride content as well as percent sodium, sulfate, and total dissolved solids. These poor quality waters may act to degrade nearby suitable waters; for that reason they will be discussed by areas starting at the upstream basin boundary at Barstow, and proceeding downstream through the basin.

Along the Mojave River, at the western boundary of the basin near Barstow, the first area of poor quality waters occurs near the industrial waste and sewage discharge plants and extends downstream for three miles toward Nebo. In this area, water from wells near Barstow on the south side of the river are rated as inferior for domestic use and marginal for irrigation use. Constituents such as fluoride and boron are the cause for the inferior rating, and waters are rated as marginal because of conductivity, sulfate, total dissolved solids, and percent sodium. Within this reach of the river total radioactivity varies from 0.5 to 39 pc/l.

The second area of ground water of marginal and inferior quality occurs between a point just south of Daggett and Gale. The area is limited to two miles in length, and apparently, the volume of degradants is so slight that within half a mile the waters become suitable again.

East of Minneola and north of Highway 66, the third group of wells with water of marginal and inferior quality is noted. High sulfates, boron, and high total dissolved solids are the basis for rating the quality as inferior; marginal waters have, in addition to the foregoing, excessive conductivity and chloride and fluoride concentrations.

The fourth, and largest area of degradation occurs around the southeast basin boundary and a line connecting the Forks-of-the-Road fault and the Cady Mountains (about 3-1/2 miles southeast, and parallel to the Mojave River). The quality of the water in this area is marginal because of high percent sodium, fluoride, boron, conductivity, and total dissolved solids. Ground water character is sodium bicarbonate in both the Troy Lake area and in the flat land area east of the Forks-of-the-Road fault except in the area indicated above, where calcium, sodium chloride, bicarbonate combinations are found.

North of the Mojave River and west of Yermo, the fifth area has sodium sulfate waters which exhibit high boron (up to 6.6 ppm), fluoride (up to 3.5 ppm), and percent sodium content, as well as levels of conductivity, total dissolved solids, and sulfates which warrant marginal ratings. Within a radius of two miles, however, the character of water changes to the more common sodium bicarbonate type, and only percent sodium indicates degradation.

The sixth area of impaired waters is near the Lower Mojave River Valley-Coyote Valley Ground Water Basins boundary, where limited ground water data indicate the existence of a small area of marginal and inferior water. The character varies, with combinations of sodium bicarbonate or sodium chloride predominating. Constituents causing an inferior rating to be assigned include fluoride, as high as 20.75 ppm, boron, and percent sodium; waters rated as marginal contain quantities of the above as well as sulfate, chloride, and total dissolved solids.

Sewage effluent from Barstow either is discharged directly to the bed of the Mojave River or is used for irrigation of crops for animal feed. This effluent has a total dissolved solids content of about 800 ppm.

A pollution problem exists downstream from Barstow owing to the waste discharges of the City of Barstow and the Atchison, Topeka and Santa Fe Railway Company. The quality of ground water has been degraded to depths of 100 feet in the alluvium underlying the Mojave River about two miles downstream from Barstow. Degradation is evidenced by tastes and odors, as well as by objectionable concentrations of synthetic detergents. At least two wells have been abandoned because of these tastes and odors.

TABLE 40

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN

LOWER MOJAVE RIVER VALLEY GROUND WATER BASIN (6-40)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
Barstow *10N/1W-31L5	DI						Na-Ca HCO_3			Municipal
-32Q1		I	D	% Na, TDS	F		Na HCO_3			Domestic Irrigation
-32J1	DI					4.8 ± 1.3	Na-Ca HCO_3			Domestic Irrigation
9N/1W-5J3			DI	EC, SO_4 TDS, % Na	F, B	0.53 ± 1.94	Na SO_4-Cl			Municipal
9N/1W-9G1		DI		F, B		9.3 ± 3.3	Ca-Na HCO_3			Domestic
Nebo 9N/1W-10G1	I	D		SO_4, F		31.9 ± 1 4.5 ± 1.8 39.0 ± 2.6	Na-Ca HCO_3-SO_4			Domestic
-15N2	DI						Na-Ca HCO_3-SO_4			Domestic
-1L1	DI						Na-Ca HCO_3			Municipal
* 9N/1E-18M1	DI						Na-Ca HCO_3			Irrigation
-6G1			DI	Ec, TDS, SO_4	B, F, % Na		Na SO_4-Cl	11-12-54	142 ft	Unknown

* F not determined D - Domestic
I - Irrigation

TABLE 40

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

LOWER MOJAVE RIVER VALLEY GROUND WATER BASIN (6-40)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
10N/1E-22Z1	I	D		F, % Na			Na HCO_3	5-20-53	300 ft	Domestic Stock
Daggett 9N/1E-9E1	D	I		% Na			Na HCO_3	4-10-52	96 ft	Domestic
-15N1	DI					8.5 $\pm$ 1(ave)	Na-Ca HCO_3			Domestic
-21H1			DI	EC, TDS	SO_4, F B, % Na		Na SO_4	9-29-58	280 ft	Unknown
Gale 9N/1E-23E1		D	I	F, B	% Na		Na HCO_3-Cl			Test
Yermo -1M1	DI					10.0 $\pm$ 2	Na-Ca HCO_3			Railroad
9N/2E-18E1	DI					4.7 $\pm$ 1(ave)	Na-Ca HCO_3			Domestic Irrigation
Minneola 9N/2E-26N1	DI						Na HCO_3	9-28-55	50 ft	Irrigation
-26E2			DI	EC, Cl	SO_4, B, TDS		Na-Ca SO_4			Irrigation
-14N1	DI						Ca-Na HCO_3	11- 5-56	31.4 ft	Unknown

D - Domestic
I - Irrigation

TABLE 40

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

LOWER MOJAVE RIVER VALLEY GROUND WATER BASIN (6-40)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
9N/2E-20K1	DI						Na HCO_3			Municipal
Newberry -25M1		DI		EC, SO_4, F TDS			Na-Ca SO_4			Irrigation
Mojave River -10D2	DI						Na-Ca HCO_3			Domestic
10N/2E-35J1	DI						Na HCO_3	4- 7-59	39 ft	Unused
Troy 9N/4E-30N1		I	D	% Na	F		Na HCO_3-Cl			Unknown
-18E1			DI	EC, B	SO_4, Cl TDS		Ca-Na Cl	8- 3-54	28 ft	Unknown
-20B1		D	I	F, B	% Na		Na HCO_3	6-30-59	11 ft	Unknown
-8D1		DI		F, % Na			Na Cl	4-10-57	21 ft	Irrigation
9N/3E-12F1	D	I		% Na			Na HCO_3	11- 5-56	33 ft	Unknown
-24D1		DI		EC, TDS			Na Cl-SO_4			Unknown

D - Domestic
I - Irrigation

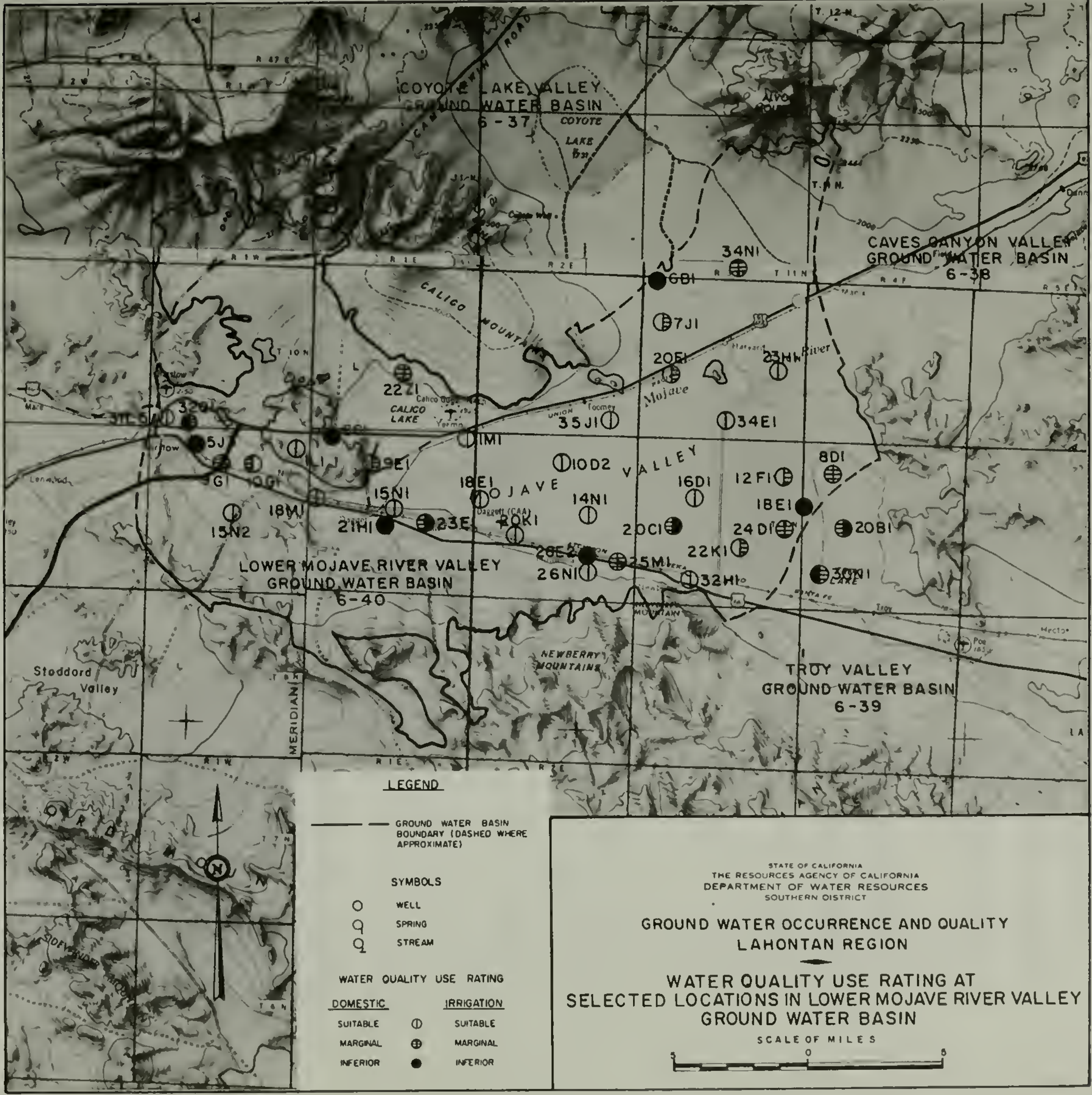
TABLE 40

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

LOWER MOJAVE RIVER VALLEY GROUND WATER BASIN (6-40)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Newberry 9N/3E-22K1	D	I		% Na			Na HCO_3-Cl	8- 7-53	45 ft	Unknown
-20C1		D	I	F, B	% Na		Na HCO_3	7-21-54	20 ft	Unknown
-16D1	DI						Na HCO_3	5-24-55	38 ft	Unknown
-32H1	DI						Na HCO_3			Unknown
Coyote-Lower Mojave 10N/3E-6B1			DI		F, B, % Na		Na HCO_3			Domestic
-7J1	D	I		% Na			Na HCO_3			Domestic Irrigation
11N/3E-34N1		DI		F, % Na			Na HCO_3			Irrigation
Mojave River 10N/3E-20E1	DI						Na HCO_3			Unknown
-23H1	DI						Na HCO_3			Irrigation
-34E1	DI						Na HCO_3			Domestic

D - Domestic
I - Irrigation


COYOTE LAKE VALLEY
GROUND WATER BASIN
6-37
COYOTE LAKE
CAVES CANYON VALLEY
GROUND WATER BASIN
6-38
CALICO MOUNTAINS
CALICO LAKE
MOJAVE VALLEY
Mojave River
LOWER MOJAVE RIVER VALLEY
GROUND WATER BASIN
6-40
TROY VALLEY
GROUND WATER BASIN
6-39
NEWBERRY MOUNTAINS
Stoddard Valley
MERIDIAN
34N1
6B1
7J1
20E1
23H1
35J1
34E1
1M1
10D2
8D1
12F1
16D1
18E1
15N1
14N1
18E1
21H1
23E1
20K1
20C1
24D1
20B1
22K1
25M1
26N1
32H1
30N1
22Z1
5J
3G1
10G1
18M1
15N2
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
SUITABLE
MARGINAL
INFERIOR
IRRIGATION
SUITABLE
MARGINAL
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN LOWER MOJAVE RIVER VALLEY
GROUND WATER BASIN
SCALE OF MILES
0
5

Middle Mojave River Valley Ground Water Basin (6-41)

Middle Mojave River Valley Ground Water Basin, shown on Figure 35, is an area of about 427 square miles, located in San Bernardino County, in the southwesterly portion of the Lahontan Region, within the Mojave River Drainage Basin (No. 19). The Mojave River, flowing from the south to the north roughly bisects the basin.

The basin is bounded on the north by alluvial divides which extend between the Kramer Hills and Iron Mountain. The Newberry and Ord Mountains border the basin on the east and southeast. To the southwest, Silver Mountain, an alluvial divide, and Shadow Mountains form the basin boundary.

The valley floor slopes gently to the east, decreasing in elevation from about 3,000 feet on the west to 2,300 feet at its eastern limit. The highest point in the mountains bordering the basin is Ord Mountain, which rises to an elevation of 6,300 feet.

Geology

The extensive alluvial divide, which forms the northern basin boundary, is interrupted by several highland areas. Included in these areas are the Kramer Hills, which consist of Tertiary volcanic rocks and sediments and pre-Tertiary granitic rocks; Iron Mountain, which consists of pre-Tertiary granitic rocks and Paleozoic metavolcanic rocks; and the hills north of Barstow, which consist of Paleozoic sediments, pre-Tertiary granitic and metamorphic rocks, and Tertiary volcanic rocks and sediments. To the east are highlands composed of pre-Tertiary granitic and metamorphic rocks, and Tertiary-Quaternary volcanic rocks and sediments.

The Ord, Stoddard, Silver, and Shadow Mountains, which consist of Paleozoic sediments, Triassic metasediments and metavolcanic rocks and pre-Tertiary granitic rocks, and an alluvial divide occur along the southern limits of the basin. Granitic hills form the western boundary of the basin.

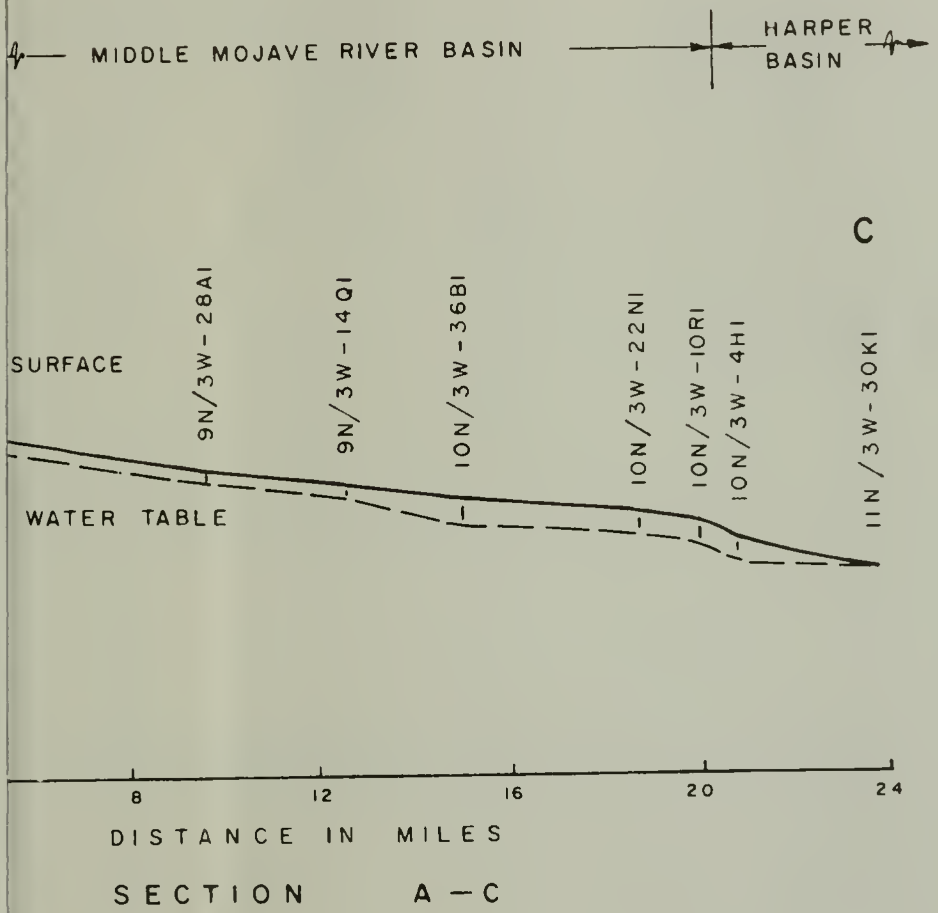
The Quaternary alluvium is exposed over much of the basin floor, comprising the upper portion of the valley fill which extends to a depth of at least 1,000 feet. Extensive deposits of Tertiary and/or Quaternary sediments occur along the course of the Mojave River west and north of Helendale, and in the area southwest of Barstow.

The northwest trending Helendale fault probably acts as a barrier to ground water movement in the older alluvial sediments.

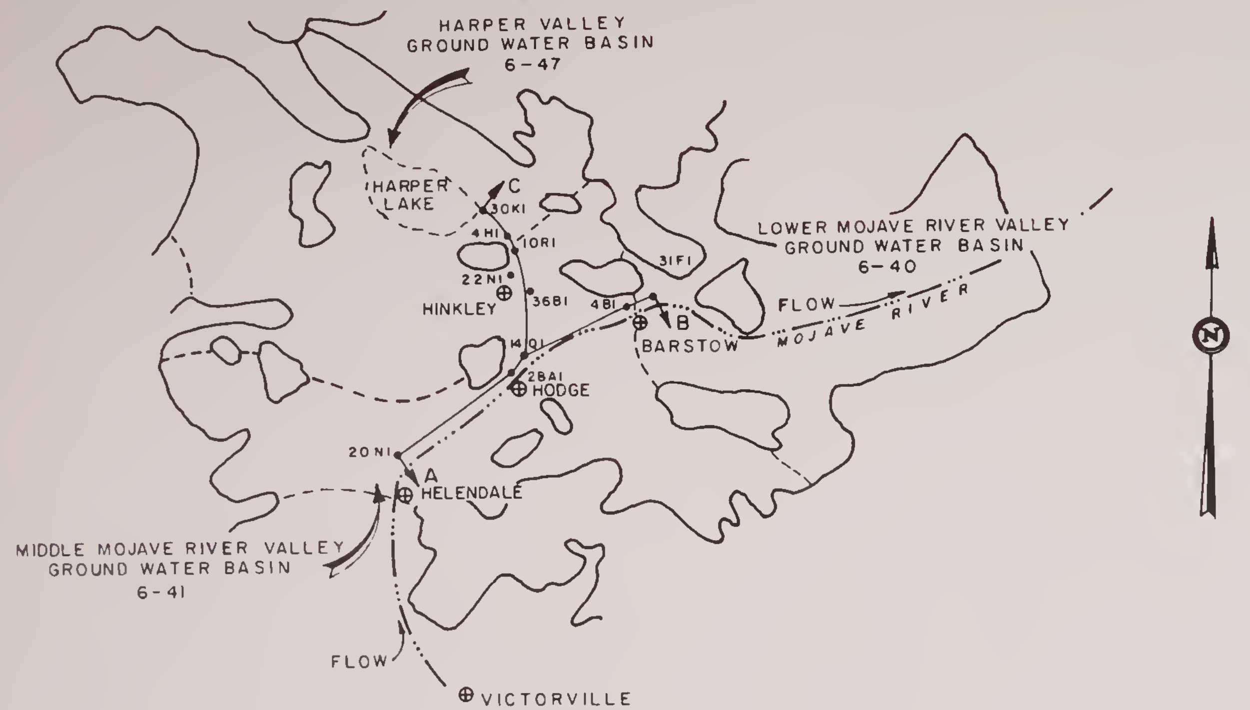
Water Supply

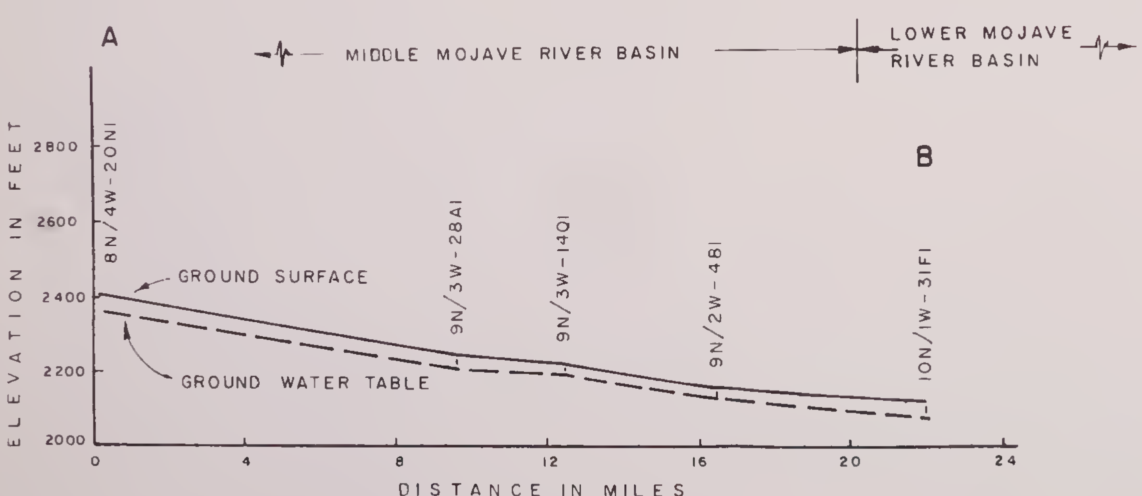
Rainfall occurs on the Middle Mojave Valley floor at a mean annual rate of four inches. At Helendale, surface inflow of the Mojave River is estimated to be about 54,000 acre-feet per year; this inflow from the Mojave River accounts for most of the recharge to the basin. Ground water moves in the unconsolidated Recent and underlying older alluvial deposits. Between Helendale and Hodge, the ground water movement follows the Mojave River, but north of Hodge it spreads out between Hinkley and Barstow, as indicated on Diagram 7. There are indications that the Harper Valley Ground Water Basin receives its greatest subsurface inflow from the Middle Mojave River basin. The remaining underflow of the Mojave River, considered to be about 30,000 acre-feet annually passes into the Lower Mojave River Valley Ground Water Basin at Barstow.

The general decline of water levels between the 1920's and 1960's is evident in this basin. In the Mojave River flood channel between

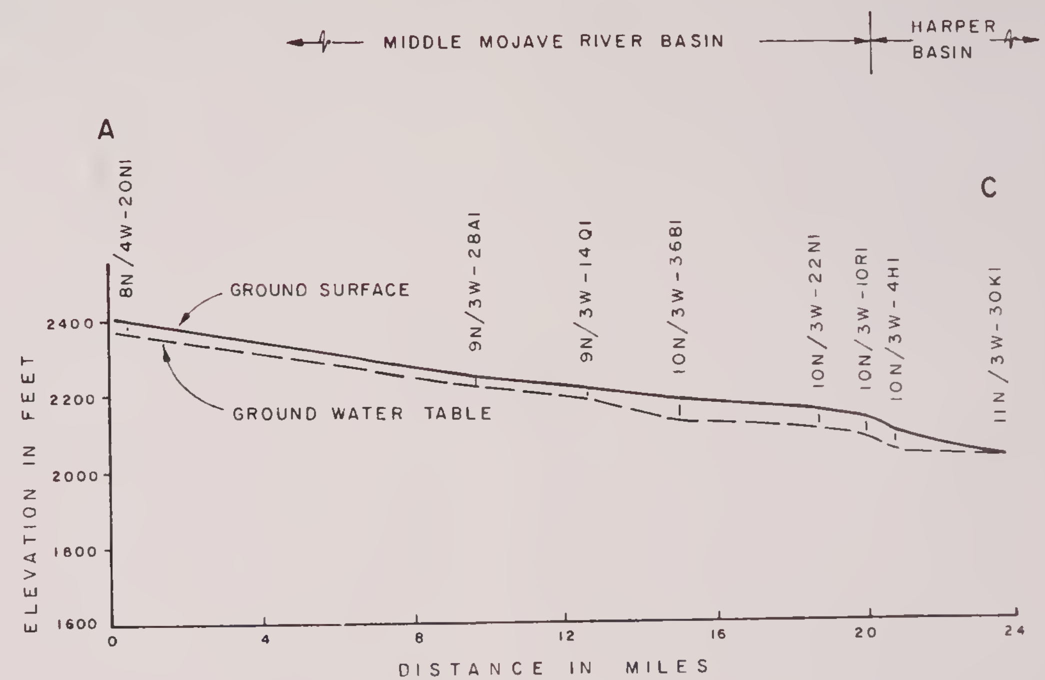


SECTION THROUGH GROUND WATER TABLE FROM MIDDLE MOJAVE RIVER VALLEY TO HARPER AND LOWER MOJAVE RIVER VALLEYS





SECTION A — B



SECTION A — C

DIAGRAM 7. SECTION THROUGH GROUND WATER TABLE FROM MIDDLE MOJAVE RIVER VALLEY TO HARPER AND LOWER MOJAVE RIVER VALLEYS

Helendale and Barstow the decline in water levels is from 10 to 20 feet. Wells in the Hinkley Valley show decreases of 20 to 30 feet. However, the depth to water is still generally less than 100 feet in the above areas, whereas in the undeveloped Stoddard Valley and West Mesa, recent readings indicate depths of over 100 feet.

Development and Utilization. The Middle Mojave River Valley Ground Water Basin shows scant development and utilization except along the Mojave River and in Hinkley Valley. Population has increased slightly in those areas where agricultural production predominates. The number of wells required for beneficial uses has increased to more than 700 by 1960. A long stem-like developed area extends from Helendale to Hodge, a distance of 12 miles, fanning out toward Hinkley Valley to the northwest and toward Barstow. Within this area, an average of 3,000 to 4,000 acres are irrigated annually. Because development is limited, ground water extractions are estimated to be about 10,000 to 15,000 acre-feet per year. Overdraft does not appear to exist at present.

Water Quality. Water quality in the basin has remained quite constant during the past forty years. The total dissolved solids content of the ground water in the valley, except for the West Mesa area, ranges from 185 to 500 ppm; the better waters are found near the river. Ground water produced from the West Mesa ranges from 700 to 1,300 ppm in total dissolved solids content. Several wells in Hinkley Valley and a few wells south of Hodge produce water in the 1,000 to 3,000 ppm range. As shown on Figure 35 and Table 41, the quality of the ground water near Helendale is generally marginal to inferior, but along the Mojave River toward Barstow,

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TABLE 41

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
MIDDLE MOJAVE RIVER VALLEY GROUND WATER BASIN (6-41)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Mojave River at Helendale 8N/4W-20N1		I	D	Cl, F, EC	SO_4, TDS		Ca-SO_4 Cl	1-10-34	11 ft	Domestic
-15G1	DI						Na-Ca HCO_3	8-28-58	28 ft	Unknown
Mojave River at Hodge 9N/3W-28A1	DI						Ca-Na SO_4-Cl	2- 9-34 10-21-58	4 ft 17 ft	Unused
-15R1	DI						Ca-Na HCO_3-Cl			Irrigation
Mojave River at Lenwood 9N/2W-6B1	DI						Na-Ca HCO_3	1-14-57	34 ft	Irrigation
Mojave River at Barstow 9N/2W-1F2	I	D		F		3.8 ± 1	Na-Ca HCO_3-SO_4			Domestic
10N/2W-30R1	DI						Ca-Na HCO_3	7- 6-32 4-13-56	17 ft 29 ft	Domestic
Southeast of Hinkley 10N/3W-27D1	DI						Na-Ca SO_4-HCO_3			Domestic
-35C1		DI		SO_4, TDS, EC		2.0 ± 1.7	Ca-Na Cl-SO_4	5-29-59	55 ft	Irrigation
South of Hinkley 10N/3W-32A4	D	I		% Na			Na HCO_3-Cl	10-23-58	50 ft	Domestic

D - Domestic
I - Irrigation

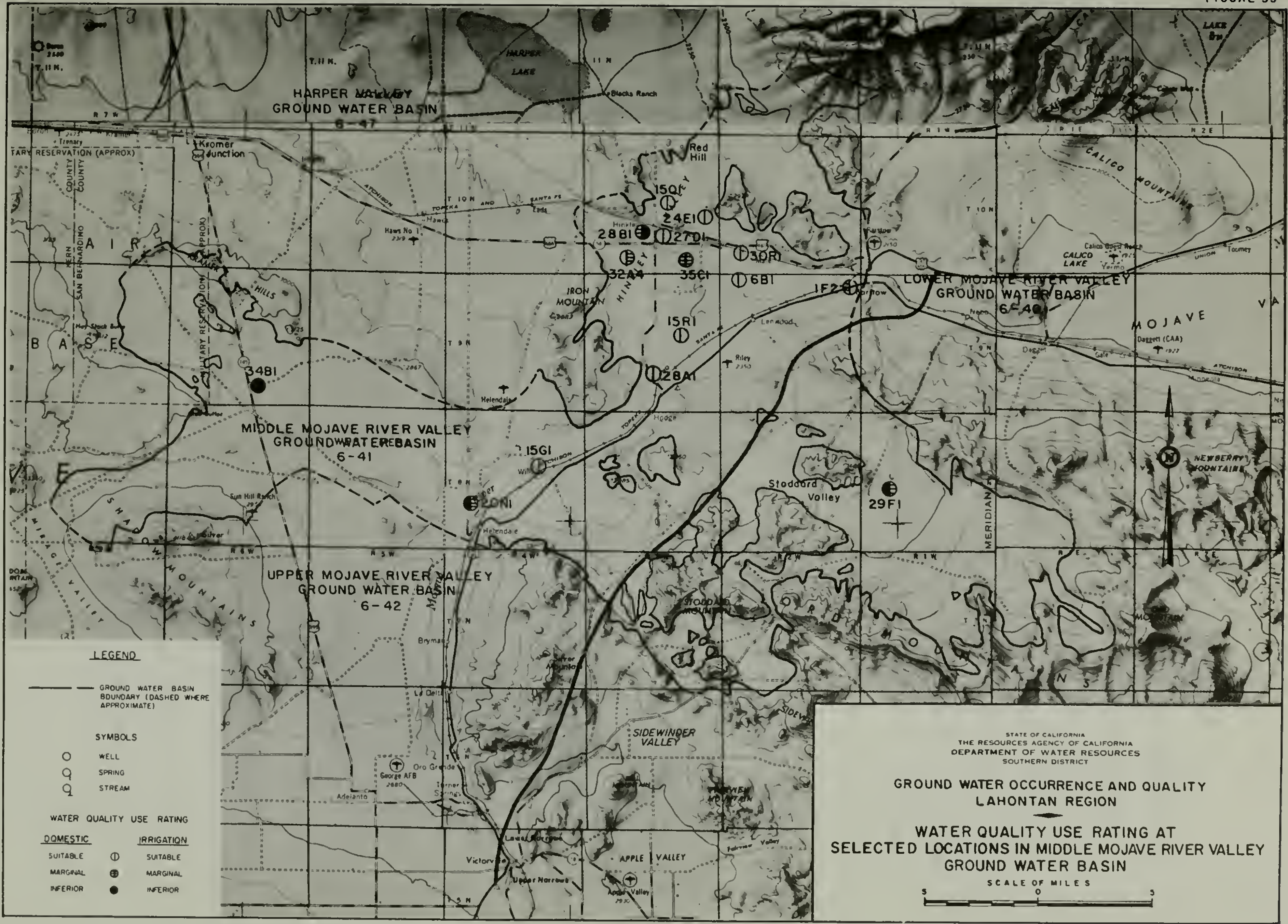
TABLE 41

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN

MIDDLE MOJAVE RIVER VALLEY GROUND WATER BASIN (6-41)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification			Water Quality Use Rating: Basis for Classification		Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
Hinkley 10N/3W-28B1		D	I	EC, SO_4, TDS	B		Na SO_4-Cl	8-18-16 1958	11 ft 39 ft	Domestic
Northeast of Hinkley 10N/3W-15Q1	DI						Na HCO_3	12-14-53 1- 8-59	47 ft 56 ft	Irrigation Domestic
East of Hinkley 10N/3W-24E1	DI						Na HCO_3	7- 6-32 1- 9-59	34 ft 60 ft	Domestic
West Mesa 9N/6W-32B1			DI	SO_4, B, TDS, EC	F, % Na		Na Cl-SO_4	5- 4-53	100 ft	Irrigation
Stoddard Valley 8N/1E-29F1		I	D	% Na	F	2.5 ± 1.7	Na HCO_3	5-27-58	80 ft	Domestic

D - Domestic
I - Irrigation


HARPER VALLEY
GROUND WATER BASIN
6-47
MIDDLE MOJAVE RIVER VALLEY
GROUND WATER BASIN
6-41
UPPER MOJAVE RIVER VALLEY
GROUND WATER BASIN
6-42
LOWER MOJAVE RIVER VALLEY
GROUND WATER BASIN
6-40
HARPER LAKE
CALICO MOUNTAINS
CALICO LAKE
MOJAVE
NEWBERRY MOUNTAINS
Red Hill
IRON MOUNTAIN
Stoddard Valley
SIDEWINDER VALLEY
APPLE VALLEY
SHADOW MOUNTAINS
MIRAGE VALLEY
Kramer Junction
Hinkley
Helendale
Barstow
Daggett (CAA)
Oro Grande
George AFB
Adelanto
Victorville
Upper Narrows
Lower Narrows
Bryman
Hodge
Lenwood
Nebo
Yermo
Sun Hill Ranch
Blacks Ranch
Hawes
Haws No. 1
MILITARY RESERVATION (APPROX)
KERN COUNTY
SAN BERNARDINO COUNTY
MERIDIAN
15Q1
24E1
28B1
27D1
32A4
35C1
30R1
6B1
1F2
15R1
28A1
15G1
20N1
29F1
34B1
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
SUITABLE
MARGINAL
MARGINAL
INFERIOR
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN MIDDLE MOJAVE RIVER VALLEY
GROUND WATER BASIN
SCALE OF MILES
5
0
5

Upper Mojave River Valley Ground Water Basin (6-42)

Upper Mojave River Valley Ground Water Basin, shown on Figure 36, is an irregularly shaped area of about 600 square miles, located in San Bernardino County, within the Mojave River Drainage Basin (No. 19).

The basin is bordered on the south by the San Gabriel and San Bernardino Mountains, on the east and northeast by Silver, Stoddard, Sidewinder, and Granite Mountains, and on the northwest by the Shadow Mountains. On the west an alluvial high extends from the Shadow Mountains to the San Gabriel Mountains.

Maximum elevations are attained in the rugged San Gabriel and San Bernardino Mountains. The valley floor ranges in elevation from 2,450 feet at the northern limit to about 4,000 feet at the southern boundary.

Geology

To the north, an alluvial divide extends between the Shadow Mountains and Silver Mountain. The Silver, Stoddard, and Sidewinder Mountains are composed largely of Triassic metasediments and metavolcanic rocks. The Granite Mountains on the east are composed of pre-Tertiary granitic rocks. The San Bernardino Mountains to the south and southeast consist largely of pre-Tertiary granitic and metamorphic rocks; the San Gabriel Mountains to the south and southwest consist of similar type rocks with some Tertiary volcanic rocks and sediments. The alluvial high on the west extends from the San Gabriel Mountains to the Shadow Mountains along the northwest corner of the basin. The Shadow Mountains consist of pre-Tertiary granitic rocks and Paleozoic sediments and metasediments.

Quaternary alluvium comprises the upper portion of the valley fill which extends to a depth of at least 1,000 feet. Extensive Tertiary and/or Quaternary sediments occur along the southern limits of the basin and along the channel of the Mojave River. Bedrock barriers at the Upper Narrows and Lower Narrows at Victorville act as an obstruction to the northwest movement of groundwater.

The Helendale fault parallels the northern edge of the basin and the San Andreas fault zone occurs in the mountains near the southern limits of the basin.

Water Supply

The principal source of replenishment to the basin is percolation of streamflow originating in the watershed. The annual precipitation varies from 5 to 8 inches on the valley floor and from 22 to 58 inches in the San Bernardino and San Gabriel Mountains. Although the area tributary to the Mojave River is only 30 miles long and 10 miles wide, an estimated annual runoff of 97,000 acre-feet occurs.

Recharge of the ground water basin begins in the upper reaches of the alluvial fans where the Mojave River emerges from the mountains; surface water is quickly absorbed in this porous material. At the south edge of Victorville the river passes through the Upper Narrows. Ground water is impeded in this area and, consequently, it rises to the surface appearing as surface flow in a perennial stream for a distance of about three miles to the Lower Narrows. After passing through the Lower Narrows, where conditions are similar to those at the Upper Narrows, the Mojave River flows across an alluvial plain, which rapidly absorbs much of the water; except in time of flood, the stream gradually dwindles in size. It usually disappears below the surface at a point several miles below Oro Grande, but owing to a subsurface constriction, rises once again and passes Helendale as surface flow. At Helendale this surface outflow is estimated to be 54,000 acre-feet per year.

Increasing ground water extractions in the Upper Mojave River Valley basin have resulted in a minor decline of water levels during the 1917-1960 period. Along the Mojave River, midway between The Forks and the Upper Narrows, water levels ranged from the surface to a depth of 55 feet in 1917. Between 1957-1960 these levels varied from 20 to 85 feet. Surface flow and ponding occurs between the Upper and Lower Narrows, but immediately below the Lower Narrows, where ground waters were found historically at depths of three to nine feet, reductions to between 20 to 60 feet are now evident. Eight miles north of Oro Grande near Bryman, water levels remained constant between 1932 and 1958, but three miles downstream it dips again from 27 to 105 feet. Finally, at the northern basin boundary, near Helendale, levels were found at 20 to 45 feet in 1930 but are now reported to be 30 to 60 feet.

Development and Utilization. Because this basin is the first in a series of basins to receive surface flow for recharge of ground water, shallow pumping has generally met the needs of the area.

The population has varied from less than a thousand in 1900 to about 16,000 in 1958. Victorville is the hub of growth wherein about half the population is centered. Apple Valley and Hesperia are experiencing increased growth due to part time farming and development of desert homesites.

The number of wells required for beneficial uses had increased from around 300 in 1917 to over a thousand in 1960. Wells are found principally along the Mojave River and in Apple Valley. On the West Mesa few wells have been drilled except near Hesperia and Adelanto. Irrigated acreage remained fairly constant at 6,000 to 7,000 acres between 1918 and 1958. The most productive lands are in the Mojave River flood plain where the irrigated alfalfa and pasture make up 80 percent of the crop income.

Industrial activity has gradually increased in the extraction of materials such as cement, talc, kaolin, and granite. Cement is processed at Victorville and Oro Grande, talc and kaolin are mined in the hills east of Bryman, and granite is quarried in the vicinity of Victorville. George Air Force Base is the only military installation in this basin but is considered to be a support rather than a primary base. As a result of these developments it is estimated that ground water extractions are in the neighborhood of 20,000 to 25,000 acre-feet per year. Overdraft does not appear to exist at present.

Water Quality. Ground water in the Upper Mojave River basin has shown signs of generally variable quality throughout the last 40 years. Although the quality of surface water from the Mojave River at The Forks has generally been suitable, when the river flow was low, the fluoride content has increased and the quality rating lowered to the marginal or inferior range. The total dissolved solids content of the ground water ranges from 85 to 400 ppm in the West Mesa area and from 400 to 1,000 ppm to the east of the Mojave River. Tabulation of water quality and use ratings at selected wells is divided into three segments on Table 42: Mojave River from The Forks to Helendale, the West Mesa, and Sidewinder Valley.

In the Mojave River bottomlands, from The Forks downstream for about eight miles, suitable waters have been found, but north of the Upper Narrows and east and northeast to Apple Valley, increases in fluoride and percent sodium generally are the basis for quality ratings of marginal for domestic uses and inferior for irrigation uses. Improvement historically occurs past the Lower Narrows from La Delta almost to Helendale, at which point greater quantities of sulfates, total dissolved solids, conductivity, and chlorides result in the water being classified as marginal for both domestic and irrigation uses. On the West Mesa generally suitable waters are found except near the northern basin boundary. On this fan a radioactivity analysis of well 4N/4W-29F1 (Hesperia Water Company) showed 16.6 pc/l in 1960, the basin's highest value to date. Sidewinder Well (6N/3W-9E4) in Sidewinder Valley, located northeast of Victorville, has a record of inferior quality water that dates back to 1917.

Victorville discharges over 700 acre-feet of sewage annually into oxidation lagoons adjacent to the Mojave River. The effluent has a high fluoride content, but is suitable for irrigation use. The total radioactivity was reported to be 9.3 pc/l at this location in 1958.

TABLE 42

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
UPPER MOJAVE RIVER VALLEY GROUND WATER BASIN (6-42)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Mojave River at the Forks 3N/3W-18L	DI						Ca-Na HCO_3	5- 3-60	flow 150 cfs	Unknown
N. of Mojave River-Forks 4N/3W-20K1	DI						Ca HCO_3-SO_4	12-21-33 10-31-56	121.4 139.8	Domestic Irrigation
4N/4W-29F1	DI					16.6 ± 1.92	Na-Ca HCO_3			Municipal
4N/3W-6D1	DI						Ca HCO_3	11- 5-56	17.3	Domestic
5N/3W-35N1	I	D		F			Na-Ca SO_4-HCO_3	11- 9-59	156.8	Domestic
Apple Valley 5N/3W-22A1	I	D		F			Ca-Na Cl	11- 7-50 11- 5-57	90.6 98	Domestic Irrigation
5N/4W-35A1		D	I	F	% Na		Na HCO_3	4-12-17 4- 5-56	0 7.3	Domestic
5N/4W-11P2	D	I		% Na			Na HCO_3-Cl	3-22-32 4-30-57	27.5 51.5	Domestic Irrigation
Upper Narrows 5N/4W-9J1	D		I		% Na		Na HCO_3			Municipal
6N/4W-32C1	DI						Na HCO_3			Domestic

D - Domestic
I - Irrigation

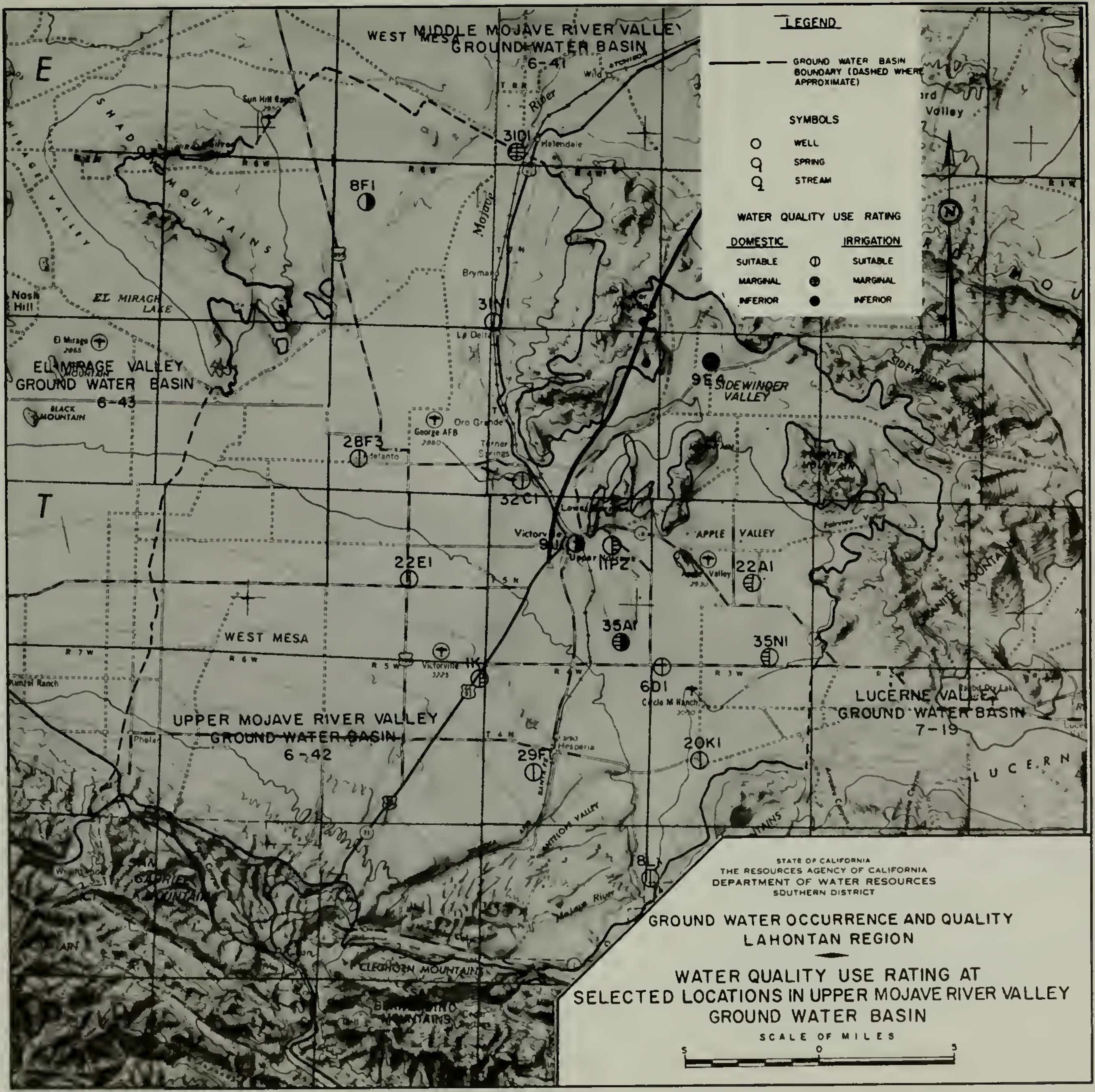
TABLE 42

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
UPPER MOJAVE RIVER VALLEY GROUND WATER BASIN (6-42)

(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Marginal	Inferior	Basis for Classification: Marginal	Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	feet or cfs	Use
La Delta 7N/4W-31N1	DI						Ca HCO_3			Domestic Irrigation
Helendale 8N/4W-31D1		DI		SO_4, TDS, EC, Cl			Na-Ca Cl	12- 8-32 6- 5-58	43.6 57	Unknown
West Mesa 4N/5W-1K1	D	I		% Na			Na-Ca HCO_3	3- 5-57	389	Unknown
5N/5W-22E1	DI						Na SO_4	1918 2-19-57	297.5 313.3	Domestic
Adelanto 6N/5W-28F3	DI						Na- Ca HCO_3	4- 5-17 1-15-58	124.3 126.8	Military
7N/5W-8F1	D		I		% Na		Na SO_4-HCO_3			Domestic
Sidewinder Well 6N/3W-9E4			DI		F, % Na		Na SO_4	2-19-18 2-27-57	29.7 30.4	Domestic

D - Domestic
I - Irrigation



STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN UPPER MOJAVE RIVER VALLEY GROUND WATER BASIN

SCALE OF MILES
5 0 5

ANTELOPE DRAINAGE BASIN (NO. 20)

El Mirage Valley Ground Water Basin (6-43)

El Mirage Valley Ground Water Basin, shown on Figure 37, is a northerly trending fan-shaped area of about 120 square miles, located along the west central border of San Bernardino County, within the Antelope Drainage Basin (No. 20).

The basin is bounded by an alluvial high and the Shadow Mountains on the northeast; on the east, an alluvial divide extends from these mountains to the San Gabriel Mountains on the south. An alluvial divide extending north from the San Gabriel Mountains to Nash Hill forms the western boundary. Nash Hill and Adobe Mountain are on the northwest border of the basin.

The San Gabriel Mountains rise to a maximum elevation of 8,505 feet in this area and Silver Peak in the Shadow Mountains attains a maximum elevation of 4,118 feet. Elevation of the alluvial-filled area varies from about 6,000 feet near the town of Wrightwood to 2,833 feet at El Mirage Lake, which covers an area of about five square miles at the north central end of the basin.

Geology

An alluvial divide, and the Shadow Mountains which consist of Paleozoic sediments and pre-Tertiary granitic rocks, occur along the north and northeastern limits of the basin. Extensive alluvial divides along the southeastern and southwestern limits of the basin converge toward the south, terminating in the pre-Tertiary granitic rocks of the San Gabriel Mountains. On the west Nash Hill and Adobe Mountain are prominent highland features of the pre-Tertiary granitic rocks.

Quaternary alluvium comprises the upper portion of the valley fill which extends to a depth of at least 392 feet. El Mirage Lake is a dry type of playa which has a hard clayey surface. Swarthout Valley, a very narrow alluvium-filled valley in the San Gabriel Mountains is the southernmost feature of the El Mirage basin.

Water Supply

The principal source of ground water replenishment in the El Mirage Valley Ground Water Basin is percolation of streamflow originating in the watershed. Precipitation ranges from about 25 inches at Wrightwood to five inches on the desert floor. Runoff from rain and melting snowpack on the San Gabriel Mountains converges in Sheep Creek and flows northward. Owing to the high permeability of the alluvial material at the mouth of Sheep Creek, surface waters quickly percolate to recharge the alluvium from which most of the ground water is obtained. The water table gradient slopes about ten feet per mile toward El Mirage Lake. The water table gradient flattens out under the lakebed which is believed to be the low point of the basin, as ground water from the northern part of the basin also appears to flow toward the dry lake.

Ground water at El Mirage Lake is found about 15 feet below the surface, but the distance to water increases progressively toward the San Gabriel Mountains where depths in excess of 500 feet are commonly found.

In the vicinity of El Mirage Lake, a slight pressure area exists. A well drilled on the south side of El Mirage Lake in 1912 produced an artesian flow when drilled to a depth of 165 feet but lost the flow when drilled deeper. Ground water in Swarthout Valley is generally found at depths of 50 to 100 feet. Water levels in the basin have not significantly changed since the early 1900's; however, levels may be seasonally lowered or movement of ground water may be altered in the area south of the dry lake during periods of heavy pumping for irrigation.

Development and Utilization. Development in the valley was originally centered around ranching and stock raising. Most of the early wells were drilled near El Mirage Lake as are many present wells due to shallower depths to ground water in that area. In 1918 approximately 60 wells existed in the valley; today an estimated 75 to 100 wells are present.

About 500 acres of alfalfa are being irrigated in an area just south of the dry lake. This is the only irrigated acreage in the basin area other than 75 acres of apple orchards near Wrightwood, which are occasionally irrigated. The remainder of the valley either is idle or is occupied by small desert homes. Many of these desert homes are not serviced by municipal water systems; owners must have water hauled by tank to their properties. At present about 700 people have permanent residence in the valley (not including weekend occupancies); about 600 of these live at Wrightwood.

About 3,000 acre-feet of water are extracted annually from the basin of which approximately 100 acre-feet are used for municipal purposes at Wrightwood. The greatest amount of water is utilized for irrigation near El Mirage Lake.

Water Quality. Ground water of suitable quality is found in the southern half of the basin but water of marginal to inferior quality is generally found in the area around the dry lake. As shown on Table 43, the main constituents causing poor quality waters are fluoride, sulfate, and percentage of sodium. Wells producing ground water rated as inferior for most uses usually have sulfate concentrations of 500 to 600 ppm, or a sodium percentage in the 90's. The total dissolved solids content of the ground water in most of the basin is around 350 ppm but increases to as much as 2,600 ppm in wells near the lakebed.

The ground water in the southern tip of the basin has a calcium bicarbonate character; ground water in the area just south of El Mirage Lake has a sodium sulfate character. Ground water on the north side of the lakebed differs from that on the south side in that chloride and sulfate become predominant anions.

TABLE 43

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
EL MIRAGE VALLEY GROUND WATER BASIN (6-43)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification			Water Quality Use Rating: Basis for Classification		Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
3N/8W-2J1	DI						Ca HCO_3	9-15-61	100 ft	Municipal
6N/7W-5B1		I	D	EC, % Na, F, TDS	SO_4		Na SO_4	1917	22.0ft	Domestic
-10L1	DI						Na SO_4	2-19-54	27.0ft	Domestic
-11R1		D	I	F	% Na	6.9 ± 1.1	Na SO_4	12-19-57	51.2ft	Irrigation
-13R1	D	I		% Na			Na SO_4			Unused
-14Q1	D	I		% Na			Na SO_4			Unused
-15C1	DI						Na SO_4	8-27-56	31.1ft	Domestic
-17Q1	I	D		F			Ca-Na SO_4	8-24-56	45 ft	Unused
-19E1	DI						Na-Ca SO_4	11- 5-52	60 ft	Domestic
7N/7W-7B1		I	D	F, EC, Cl, TDS	SO_4		Na SO_4-Cl	2-19-54	45.1ft	Unused

D - Domestic
I - Irrigation

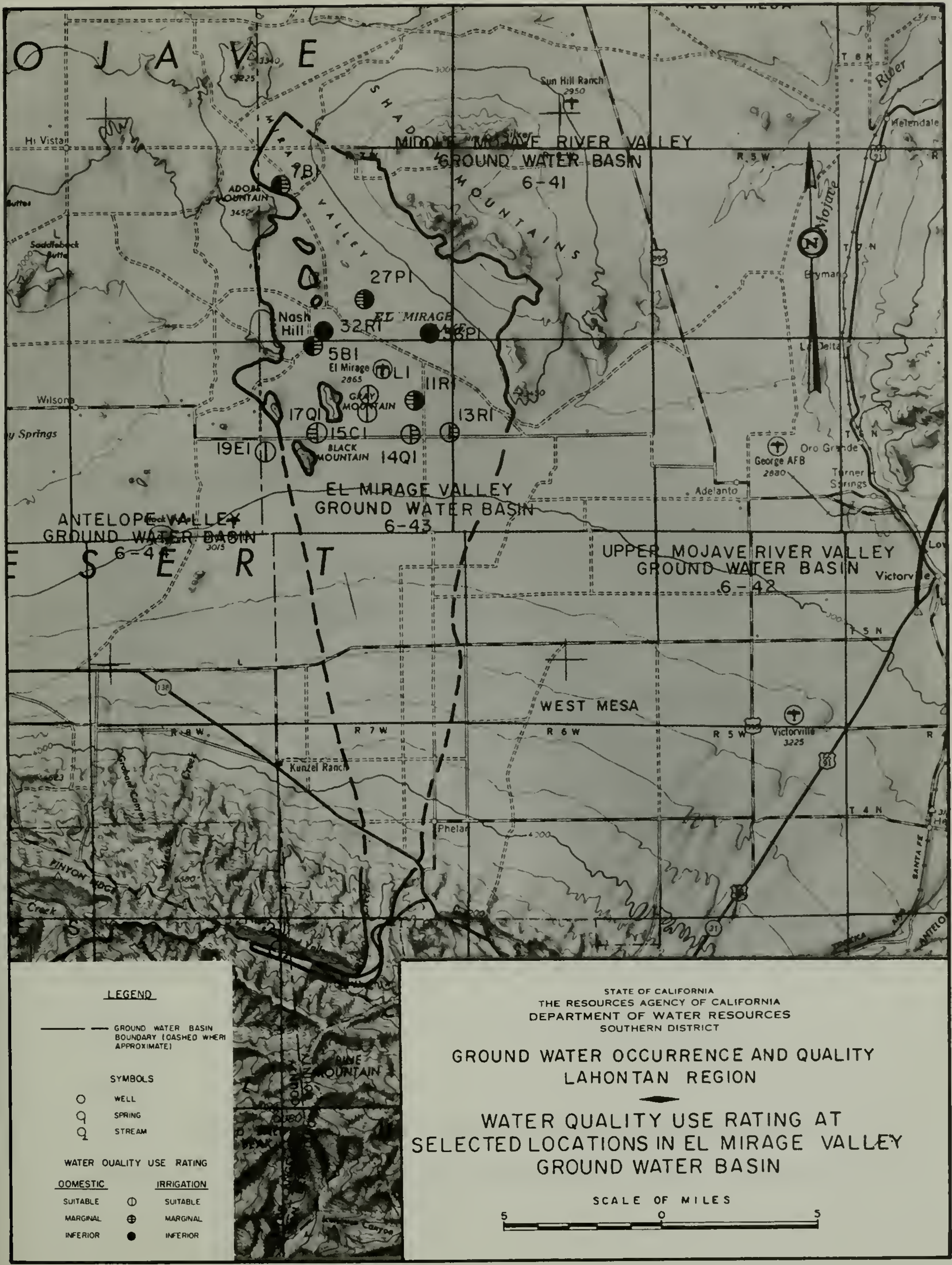
TABLE 43

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
EL MIRAGE VALLEY GROUND WATER BASIN (6-43)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
7N/7W -27P1		D	I	F	% Na	0.7 $\pm$ 1.0	Na SO_4-Cl	2-19-54	15.6ft	Domestic
-32R1			DI	% Na	SO_4, EC, TDS, Cl		Na Cl-SO_4	8-14-56	25.9ft	Unused
-36P1			DI	B	F, Cl, SO_4 EC, TDS, % Na		Na Cl	3-17-55	37.0ft	Unused

D - Domestic
I - Irrigation

FIGURE 37



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SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN EL MIRAGE VALLEY GROUND WATER BASIN

Antelope Valley Ground Water Basin (6-44)

Antelope Valley Ground Water Basin, as shown on Figure 38, is a triangularly shaped area of about 1,615 square miles located in the southwesterly portion of the Lahontan Region, in the Antelope Drainage Basin (No. 20). The basin encompasses portions of Los Angeles, Kern and San Bernardino Counties.

This basin is bounded on the northwest by the Tehachapi Mountains, on the south by the San Gabriel Mountains, and their westerly extension, the Sierra Pelona Range. Alluvial divides form portions of the northeastern and northwestern boundaries.

Antelope Valley has been divided into eight subbasins, the boundaries of which are delimited on Figure 38. These include the Rock Creek, Buttes, Chaffee, Gloster, North Muroc, Willow Springs, Neenach, and Lancaster Subbasins. The subbasins are separated by discontinuous ridges of basement rock either exposed at the surface or underlying several feet of residual cover. The boundaries of these subbasins have been delineated on the basis of marked changes in ground water elevations. Where some doubt was present as to the location of the basin's limits, natural drainage divides were used as the boundary.

Three dry lakes, Rosamond Dry Lake, Rogers (Muroc) Lake, and Buckhorn Lake, are located in the central part of the basin. The lowest elevation in the basin, 2,270 feet, occurs in Rogers Lake.

Geology

Antelope Valley is a graben or downthrown block bounded on the northwest by the Garlock fault, along which the Tehachapi Mountains have been uplifted, and on the southwest by the San Andreas fault zone, along which the San Gabriel Mountains and their westerly extension, the Sierra Pelona Range, have been uplifted. Granitic highlands occur on the north and east. The valley is divided into eight areas by alluvial highs and/or by discontinuous ridges of exposed or buried bedrock. Rocks of all types from Precambrian to Recent surround or crop out within the valley.

The Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 1,300 feet. Tertiary and/or Quaternary sediments are prominent along the foothills of the Tehachapi Mountains and the Sierra Pelona Range. A pressure area exists in the vicinity of Rosamond Dry Lake and Buckhorn Lake which are compound types of playas and Rogers (Muroc) Lake, a dry type of playa. Sand dunes occur in the vicinity of the dry lakes, especially around Buckhorn Lake.

Water Supply

Precipitation occurs primarily on the San Gabriel Mountains where as much as 45 inches annually has been recorded, but on the valley floor it ranges between four and eight inches. Nearly one-half of the tributary mountain runoff is due to the flows of Big Rock and Little Rock Creeks at the southeast corner of the basin. Other perennial streams are Oak and Cottonwood Creeks, which originate in the mountains to the west. The remainder of runoff to the valley is supplied by intermittent and ephemeral streams. The estimated mean seasonal runoff amounts to 66,000 acre-feet. Most of the precipitation on the mesa and valley floor, estimated to be 679,000 acre-feet per year, either evaporates or is consumed by crops and natural vegetation. Consequently, this contribution of precipitation to the underground supply is not significant.

Recharge of ground water begins in the upper elevations of the alluvial fans, principally in Rock Creek and Buttes Subbasins and flows into the southeast corner of Lancaster Subbasin. The westerly portion of Lancaster Subbasin is fed by underflow through alluvium in Neenach Subbasin. Subsequently, underflow from Lancaster Subbasin probably moves northward toward Fremont Valley. Because present pumping depresses ground water levels, underflow from the Lancaster Subbasin is slight. Within this subbasin the principal water-bearing zone extends to depths of 600 feet and is separated from the deeper zones by a south dipping clay bed. The deeper zones are apparently recharged directly from the west by percolation of runoff from the Tehachapi and San Gabriel Mountains. There is little evidence of the clay member in the southern and western portions of the valley. Apparently, the principal and deep water-bearing zones merge in these areas, resulting in a single aquifer.

<u>Development and Utilization</u>. Because Antelope Valley is a closed basin, virtually all surface flows, except for infrequent flood flows, are diverted or used for replenishment of ground water. Small surface diversions are made in the Rock Creek and Buttes Subbasins, but the remainder of the subbasin demand is supplied by pumping from the ground water reservoir.

Population growth fluctuated until 1940, after which a sharp increase to the present 70,000 took place, as shown on Diagram 8. The towns of Lancaster and Palmdale have grown since 1940 and now make up one-half, and one-quarter of the valley population, respectively.

Boron, looking east

Spence Air Photos

Open pit borate mine and adjacent processing plants.

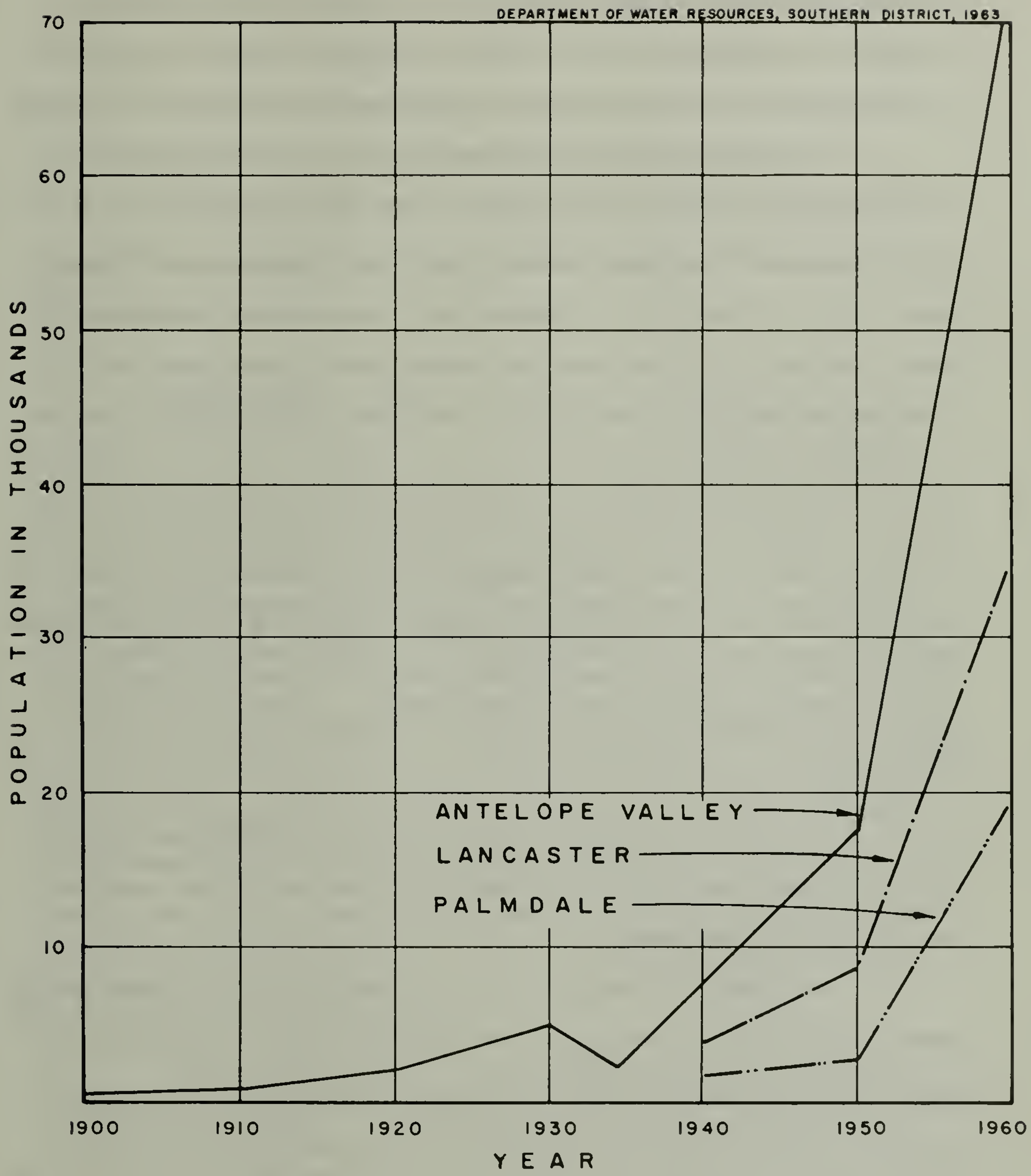


DIAGRAM 8. POPULATION TREND IN ANTELOPE VALLEY

The number of wells required over the years has increased from a few low producing domestic wells to 1,400 generally high producing, municipal and irrigation wells in 1959. Initially, wells were located in the vicinity of Lancaster, but now are dispersed throughout the valley.

Irrigated acreage has followed the same growth pattern with crop production reaching a high in 1950. The main irrigated crop, alfalfa, was the source of 75 percent of the total income from crops in 1953 and ground waters extracted for irrigation of this crop were responsible for about 80 percent of the net draft on ground water. There have been indications recently that production of irrigated crops is falling off due to uneconomic pumping costs.

In the past decade the greatest surge of development involved industrialization and associated commercial developments. Five major aircraft companies have located at the Palmdale Airport, a $12 million cement plant has been constructed near Mojave, and a 30 percent increase in the production of boron at Boron have provided the major impetus to this development.

Based on this pattern of ground water development and utilization the average extraction is estimated to be around 200,000 acre-feet annually for the last decade.

Development of Antelope Valley, accompanied by increased pumping draft, is indicated by steadily declining water levels. Water levels at well 7N/10W-19D1 are considered representative of the historic decrease in water levels in the basin with a drop of 151 feet observed for the period 1932-60. During the period 1928-60 a drop in water level of approximately 140 feet occurred at well 6N/12W-24C1 near Palmdale. Depths to ground water vary from 10 feet, south of Rosamond Dry Lake to 380 feet in the Rock Creek area. The present depth to ground water indicates that declines are persisting except in the Rock Creek Subbasin. Ground water extractions in the Lancaster and Palmdale areas are continuing to lower water levels at the rate of one to six feet per year.

Cumulative overdraft in Antelope Valley Ground Water Basin is estimated to be in excess of 1.5 million acre-feet, and exceeds that of any other ground water basin in the region.

Water Quality. Within the confines of Antelope Valley basin the mineral quality of ground water has remained unchanged during the past 50-year record. Major surface flows, principally from Big Rock and Little Rock Creeks, have consistently exhibited suitable mineral quality. The total dissolved solids content of the ground water in the Antelope basin generally ranges from 200 to 400 ppm except for the area around the dry lakes and near Boron. Concentration of total solids in ground water from sources near Rogers Lake, and north throughout most of the North Muroc Subbasin, generally range from 500 to 1,500 ppm. In order to measure chemical constituents in ground water, a series of key wells were selected in each of the eight subbasins that compose the basin. These wells and the corresponding water quality rating of their waters are plotted on Figure 38 and tabulated on Table 44.

In Rock Creek Subbasin four key wells have been selected to gage ground water outflow. These wells are within three miles of the Rock Creek-Buttes boundary and have had water of suitable mineral quality. The character ranged from sodium sulfate to sodium-calcium chloride-sulfate in 1960.

In Chaffee Subbasin, at the northern extremity, water from two key wells at the southeast boundary was checked for quality. The water is suitable for domestic and irrigation purposes and ranged in character from sodium-calcium bicarbonate to calcium-sodium sulfate-bicarbonate between 1955 and 1959.

Three key wells were utilized to evaluate the water quality in Gloster Subbasin. Water from the two western wells was of suitable quality for all beneficial uses, but water from the eastern well was inferior in quality due to a high percent sodium, which affects irrigation use. Water from both the western and eastern wells has a sodium bicarbonate-sulfate character, although water from well 10N/12W-21M1 exhibited a calcium sulfate character during 1960.

Three ground water sources were used to evaluate the water quality in Willow Springs Subbasin. Willow Springs, from 1908 to 1960, formed the largest group of springs in Antelope Valley and its sodium bicarbonate-sulfate waters were of suitable quality. The other two key wells, located north and northeast of Willow Springs, produce water suitable in quality, and of a sodium-calcium sulfate and sodium-calcium bicarbonate-sulfate character, respectively.

Ground water sampling in Neenach Subbasin has been concentrated in the southern half. Most analyses indicate the waters to be suitable for domestic and irrigation use. Three key wells have been selected to monitor the outflow quality. Within the last decade waters from these wells have ranged in character from calcium bicarbonate to sodium-calcium bicarbonate.

Although 30 analyses were made of ground water from wells in North Muroc Subbasin, none of the analyses indicated the water to be suitable for benefical uses. In fact, the quality of the water appears equally divided between marginal and inferior. Water for most of the analyses was obtained from wells north of U.S. Highway No. 466, in a generally continuous east-west line emanating at Boron and extending west for 12 miles. Three key wells were selected from this group as representative of the water quality situation in this subbasin. At the west edge, the quality is rated as marginal because of the high percent sodium. From this point east to the basin boundary, waters rated as inferior appear to the south, and waters rated as marginal to the north; these ratings result from the high sodium, boron and fluoride content of the water. The character of the water, moving easterly, varies from a sodium bicarbonate to a sodium chloride-sulfate.

Lancaster Subbasin is the largest unit in the Antelope Valley basin. It is at a lower elevation and ringed by most of the other subbasins; consequently, they contribute to the underground flow and ultimate composition of its waters. Analyses of water from sixteen key wells in the Lancaster Subbasin indicate the transition of suitable to inferior quality waters. Buttes Subbasin, for example, adds a band of ground waters of suitable quality which extends five miles into the southern reaches of Lancaster Subbasin. Willow Springs and Neenach Subbasins also contribute a band of suitable quality ground waters extending ten or more miles within the subbasin, to U.S. Highway 6. In the vicinity of Oban, however, marginal waters have recently displaced suitable waters. Further east around Rosamond Lake, ground waters of inferior quality extends six miles north-south and nine miles east-west. North Muroc Subbasin also supplies waters of inferior quality to the northeastern corner of Lancaster Subbasin. These waters pond under Rogers Lake in an erratic band extending up to nine miles within the subbasin.

TABLE 44

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

ANTELOPE VALLEY GROUND WATER BASIN (6-44)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Rock Creek 5N/10W-4R1	DI					5.8 ± 1.6	Ca HCO_3			Domestic
5N/11W-13G1	DI					5.8 ± 1.6	Ca-Na SO_4	12-13-56	227 ft	Domestic Irrigation
6N/8W- 18D1	DI					0 ± 0.9	Na-Ca Cl SO_4			Domestic
6N/9W- 34R1	DI					9.6 ± 1.6	Na-Ca HCO_3			Irrigation
Buttes 5N/11W-4E1	DI						Ca HCO_3			Irrigation
6N/9W- 6L1	DI						Na-Ca HCO_3- SO_4			Domestic
6N/10W-20M1	DI					5.2 ± 1.4	Ca HCO_3- Cl			Irrigation
Chaffee 11N/11W-8D1	DI						Na HCO_3	1918 2-27-30 10-21-55	205 ft 218 ft 198 ft	Unused
11N/12W-26J1	DI					17.1 ± 3.1	Na-Ca HCO_3	1918 3- 1-30 9-27-55	155 ft 158 ft 156 ft	Unused
-32E1	DI						Ca-Na SO_4- HCO_3			Domestic

D - Domestic
I - Irrigation

TABLE 44

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN ANTELOPE VALLEY GROUND WATER BASIN (6-44)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Gloster 10N/11W-8E1		D	I	F	% Na	2.4 ± 1.8	Na HCO_3-SO_4	9-18-52 11- 2-55	47 ft 55 ft	Domestic
10N/12W-21M1	I	D		SO_4		-0.3 ± 1.5	Ca SO_4			Domestic
10N/13W-24F1	DI					16.2 ± 1.0	Na HCO_3-SO_4	11- 2-29 9-20-51	179 ft 185 ft	Domestic
Willow Springs 9N/13W-7Q1	DI					1.7 ± 1.5	Na HCO_3-SO_4	11-14-29 2-10-53	3 ft 3 ft	Domestic
10N/13W-32M1	DI						Na-Ca HCO_3-SO_4	1-20-53 5-21-56	132 ft 162 ft	Domestic Irrigation
10N/14W-25R1	DI						Na-Ca SO_4			
Neenach 8N/15W-13R1	DI						Na HCO_3			Irrigation
-36M1	DI						Ca HCO_3	3- 7-57	78 ft	Domestic
9N/14W-32C1	DI					2.8 ± 1.3	Na-Ca HCO_3	12-18-56	190 ft	Irrigation
North Muroc 11N/7W-32N1		D	I	TDS, F, SO_4, EC	B, % Na	59.2 ± 1.85	Na Cl-SO_4			Industrial

D - Domestic
I - Irrigation

TABLE 44

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
ANTELOPE VALLEY GROUND WATER BASIN (6-44)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	feet or cfs	Use
North Muroc 11N/9W-28K1	D		I		% Na	2.0 ± 1.4	Na HCO_3	5-16-56	89 ft	Domestic
-31C1	D	I		% Na		1.1 ± 0.9	Na Cl	5-15-56	200 ft	Domestic
Lancaster 7N/11W-9P1	DI					18.1 ± 1.0	Ca HCO_3-SO_4	11-21-56	129 ft	Domestic
-16B1	DI						Ca HCO_3			Unknown
8N/9W-4P2		D	I	F	% Na		Na HCO_3-SO_4	10-20-54	40 ft	Domestic
8N/10W-2F1	DI						Na-Ca HCO_3			Military
-26Q1	DI						Na-Ca HCO_3			Unknown
-30B1	DI					-0.1 ± 1.2	Ca-Na HCO_3	8-15-53	107 ft	Irrigation
8N/11W-21R1	DI					2.9 ± 1.7	Na-Ca HCO_3			Domestic
8N/12W-9B1	D	I		% Na			Na HCO_3	7- 7-59	12 ft	Domestic

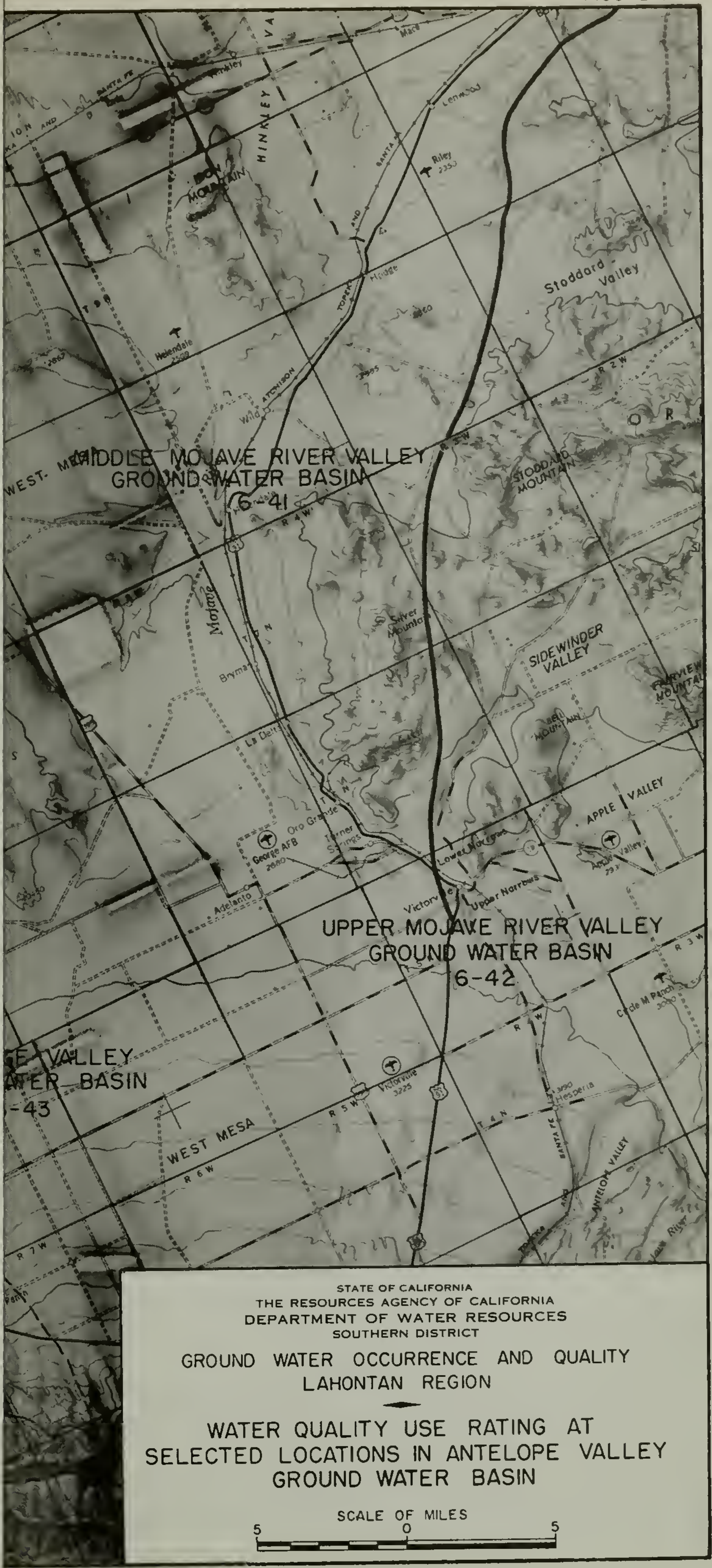
D - Domestic
I - Irrigation

TABLE 44

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
ANTELOPE VALLEY GROUND WATER BASIN (6-44)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Lancaster 8N/12W-34P2	DI					1.1 ± 1.2	Na-Ca HCO_3			Domestic
9N/9W-18C1	DI						Na HCO_3	6-14-59	21 ft	Military
9N/12W-24J1			DI		F, % Na		Na HCO_3			Domestic
-27Q1	DI					15.1 ± 2.1	Na HCO_3			Irrigation

D - Domestic
I - Irrigation



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GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN ANTELOPE VALLEY
GROUND WATER BASIN

SCALE OF MILES
5 0 5

LEGEND

——— — — GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)

SYMBOLS

○ WELL

SPRING

STREAM

WATER QUALITY RATING

DOMESTIC		IRRIGATION
SUITABLE	⦶	SUITABLE
MARGINAL	⊕	MARGINAL
INFERIOR	●	INFERIOR

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WATER QUALITY USE RATING AT SELECTED LOCATIONS IN ANTELOPE VALLEY GROUND WATER BASIN

SCALE OF MILES
5 0 5

SEARLES LAKE DRAINAGE BASIN (NO. 21)

SEARLES LAKE DRAINAGE BASIN (NO. 21)

Proctor Valley Ground Water Basin (6-45)

Proctor Valley Ground Water Basin, shown on Figure 39, is a small irregularly shaped east-west trending basin of about 22 square miles, located in the south central portion of Kern County, within the Searles Lake Drainage Basin (No. 21).

The basin is bounded on the north by the Sierra Nevada and on the south by the Tehachapi Mountains. An alluvial high forms the western limits of Proctor Valley basin.

Highest point in the highlands bordering the basin is Double Mountain in the Tehachapis at an elevation of 7,998 feet. The floor of the basin ranges in elevation from about 5,000 feet to 3,900 feet at Proctor Lake; this dry lake has an area of 1.2 square miles.

Geology

The Paleozoic sediments, pre-Tertiary granitic rocks, and Tertiary sediments of the Sierra Nevada occur to the north and east; Paleozoic sediments and pre-Tertiary granitic rocks of the Tehachapi Mountains are the predominant rock types to the south. An alluvial high occurs to the west between Monolith and Tehachapi.

The Quaternary alluvium comprises the upper portion of the valley fill which extends to a depth of at least 720 feet. Near Proctor Lake, an intermittent type of playa, the Quaternary alluvium extends to a depth of about 200 feet.

Water Supply

The principal sources of water supply in the basin are deep penetration of direct rainfall and percolation of streamflow originating in the watershed. Average annual precipitation is about ten inches on the valley floor.

The west side of the basin is a surface drainage divide. Runoff waters west of this divide flow to Tehachapi Creek northeast to San Joaquin Valley. Surface drainage to the east of this divide either ponds in Proctor Lake or flows down Cache Creek toward Fremont Valley. Water ponds in Proctor Lake due to a slight surface drainage divide between Proctor Lake and Cache Creek.

The areas of Whiterock, Sand, and Cache Creeks are the main recharge areas of the Proctor basin and are capable of a moderate recharge rate. Usable ground water supplies are derived from the Recent and underlying older alluvial deposits.

Under natural conditions ground water flow was probably split near the divide between Proctor basin and the Tehachapi area and moved toward the east and west, respectively. Although there is still some ground water outflow to both east and west, movement of ground water has been altered by heavy pumping in areas south of Tehachapi and Monolith. A water table gradient of 40 feet per mile slopes from the north and south sides of the basin to its central axis. The hydraulic gradient varies from 10 to 30 feet per mile, sloping to the east or west along the central axis.

Water levels have fallen approximately 50 feet in some areas of the basin. Wells on the eastern edge of Proctor Lake once produced artesian flows but these wells have not flowed since 1947. These artesian flows were caused in part by an upper confined aquifer which has since been drained of its water. In 1961, the ground water table was about 60 feet below Proctor Lake; depth to water increases on the higher slopes.

Development and Utilization. A great number of wells are spread throughout the valley because ground water is the only source of water in the basin. Water is used for irrigated agriculture, for industrial uses of the Monolith Cement Company, and for domestic purposes. Some water has been exported to Mojave by the Mojave Public Utility District. About 15,000 acre-feet of water is extracted from the basin annually.

The major use of ground water is for irrigated agriculture, which is declining, due partially to a continued lowering of the water table. In 1952 the irrigated agriculture in the basin area was about 3,000 acres, but in 1961 it had dropped to about 800 acres. The major crop produced is alfalfa, while the balance is comprised of various row crops. Although the Tehachapi Valley area has a population of about 3,000, only 500 persons live in the area of the Proctor Valley basin, with the majority located near Monolith.

Water Quality. The ground water of the valley is generally of suitable quality with the exception of a few wells which produce water slightly high in fluorides, as shown on Table 45. Fluoride concentrations which cause marginal quality water for domestic purposes average about 0.9 ppm. Water from well 32S/33E-34B1, in the southeast end of the valley, has been rated as marginal due to a nitrate concentration of 56 ppm. Nitrate concentrations throughout the basin average about 16 ppm.

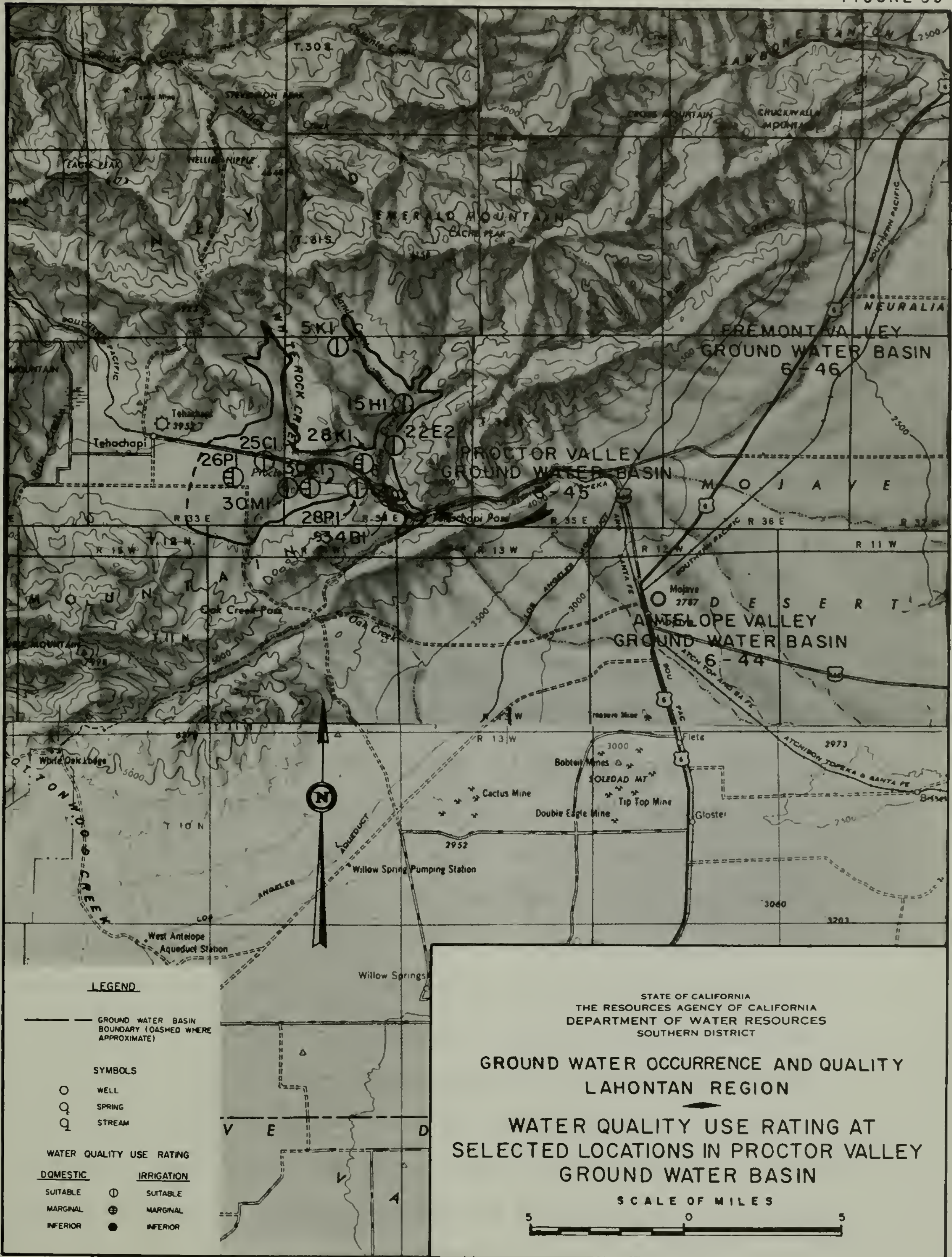
The character and the total dissolved solids content of the ground water in the Cache Creek area are notably different from those of the water in the rest of the basin. The water in the Cache Creek area is mostly sodium-calcium bicarbonate-sulfate in character; the ground water in the rest of the basin, mainly calcium bicarbonate. The total dissolved solids content of the ground water in the Cache Creek area averages 567 ppm, which is greater than the average 338 ppm found in the rest of the basin. The mingling of the Cache Creek area ground water with that from the main part of the basin is indicated by a change in character (to sodium bicarbonate) and by an increase in total dissolved solids content (to 408 ppm) in water from well 32S/34E-34B1.

TABLE 45

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN
PROCTOR VALLEY GROUND WATER BASIN (6-45)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
32S/33E-25C1	DI					6.3 ± 1.2	Ca HCO_3	10-24-61	101.3ft	Domestic
-26P1	I	D		F			Ca-Na HCO_3			Irrigation
32S/34E- 5K1	DI					4.5 ± 1.0	Na-Ca SO_4 - HCO_3	10-24-61	23.0ft	Unknown
-15H1	DI						Na-Ca HCO_3-SO_4	12-17-54	26.8ft	Stock
-22E2	DI						Na-Ca HCO_3-SO_4	10-24-61	98.7ft	Unknown
-28K1	I	D		F		4.1 ± 0.9	Ca HCO_3	10-24-61	69.0ft	Stock
-28P1	DI						Ca HCO_3			Unknown
-30K1	I	D		F			Ca HCO_3			Irrigation
-30M1	DI					7.4 ± 1.4	Ca HCO_3			Industrial
-34B1	I	D		NO_3		4.7 ± 1.0	Na HCO_3			Domestic

D - Domestic
I - Irrigation



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GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN PROCTOR VALLEY GROUND WATER BASIN

SCALE OF MILES
5 0 5

Fremont Valley Ground Water Basin (6-46)

Fremont Valley Ground Water Basin, as shown on Figure 40, is a bow-shaped basin of about 331 square miles, located at the southwestern corner of the Lahontan Region in Kern County. The basin lies within the Searles Lake Drainage Basin (No. 21).

This basin is bounded on the north by the El Paso Mountains, and on the east by the Rand Mountains. An alluvial high forms the southern boundary, and the Sierra Nevada, the western boundary.

The highest point in the valley is Cache Peak which rises to about 6,700 feet. The central and lowest part of the basin is occupied by Koehn Lake; this dry lake has an area of about 5.0 square miles, and stands at an elevation of about 1,900 feet.

Geology

The Garlock fault zone, which defines the north and northwest limits of the basin, extends along the abruptly rising southeastern face of the Sierra Nevada and El Paso Mountains. The Sierra Nevada consists predominantly of Paleozoic sediments and pre-Tertiary granitic rocks. The El Paso Mountains contain these same rock types and, in addition, include pre-Tertiary metamorphic rocks and Tertiary and/or Quaternary sediments. Tertiary volcanic rocks occur in the Summit Range and Klinker Mountain to the north and northeast. To the east, the Rand Mountains and their southerly extension consist of Precambrian metamorphic rocks and pre-Tertiary granitic rocks. Castle Butte on the southeast corner of the basin consists of pre-Tertiary granitic rocks and Tertiary volcanic rocks. The southern limit of the basin is an alluvial high which joins the granitic highlands and the Sierra Nevada to the west.

Quaternary alluvium comprises the upper portion of the valley fill which extends to a depth of at least 1,190 feet. The Muroc fault acts as a partial barrier to the northerly movement of ground water toward Koehn Lake. This lake is a moist, salt-encrusted type of playa, around which a pressure area exists.

Water Supply

The sources of ground water replenishment to the basin are deep penetration of direct rainfall and percolation of streamflow originating in the watershed. The annual precipitation varies from 5 to 7.5 inches on the valley and from 10 to 20 inches in the Sierra Nevada. The character of surface runoff emanating from the Sierra Nevada is of high intensity and short duration. This feature affords a maximum recharge value and a minimum loss to evaporation. Subsurface inflow to the basin occurs principally around the southern basin boundary between the Chaffee-North Muroc Subbasins in Antelope Valley basin and Fremont Valley basin.

In the Chaffee area, a partial barrier has been formed by the Muroc fault that impedes but does not prevent subsurface flow from moving into the Fremont Valley basin toward Koehn Lake as indicated on Diagram 9 (Section A-C). Usable ground water supplies are derived from the Recent and underlying older alluvium. Water level measurements in this area show that ground water occurs about 200 feet below the surface in Chaffee Subbasin and at about 500 feet just north of the Muroc fault. Subsurface inflow from the North Muroc Subbasin of the Antelope Valley basin also takes place at the alluvial narrows between Castle and Desert Buttes.

The hydraulic gradient between the alluvial narrows and Koehn Lake flattens from 11 feet per mile to about 7 feet per mile, as shown on Diagram 9 (Section B-C). Historic water levels along this alignment have dropped from 10 to 15 feet just north of the narrows and up to 35 feet at the west side of Koehn Lake. Ground water moves from all directions toward Koehn Lake.

Recharge to the basin across the Garlock fault is impeded by displacement of the fault as indicated by the difference in water levels on opposite sides of the fault. Flowing springs existing about two miles southwest of the town of Garlock on the north side of the fault are further evidence of the restricted underflow.

Ground water extractions have increased over the years, and a moderate lowering of the water table has occurred. Artesian flows still occur near Koehn Lake.

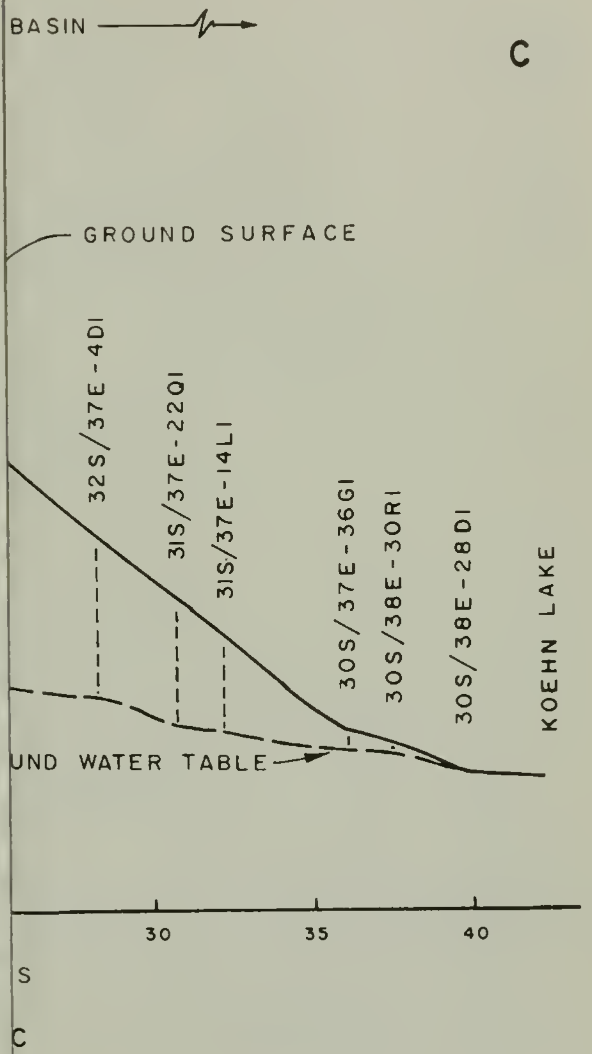
Development and Utilization. Historically, Fremont Valley Ground Water Basin has maintained a limited agricultural economy utilizing ground water extractions. Most of the development has been restricted to an area around Cantil, where soil and water conditions are conducive to fine agricultural production. A few small agricultural developments have also occurred near California City and northeast of Koehn Lake. Mining activities have been conducted in the basin area with gold, silver, and tungsten being extracted near Randsburg at various periods between the early 1900's and 1940's. Salt production has taken place principally at Saltdale on Koehn Lake. The population of the basin area has, on occasions, exceeded 500 persons but, as a rule, not more than 300 persons live in the basin area. The towns of Garlock, Saltdale, and Cantil have never developed into centers of population; of these towns, Cantil is considered to be most developed.

The number of wells required over the years for basin development has increased from about 50 in 1918 to more than 170 in 1960. Their distribution has remained quite static, with a concentration in the artesian area west of Koehn Lake, and a valley-wide dispersion of the remainder. Most large irrigation wells produce more than 500 gpm, however, yields as much as 4,000 gpm have also been reported in the basin. Artesian flows are sufficient to coat portions of Koehn Lake with a thin sheet of water which dissolves the efflorescent salts. Brine thus formed yields salt and gypsum upon evaporation and limited mining operations have thereby been established.

Irrigated agriculture has accounted for the bulk of economic development with an estimated 8,000 acres planted in 1958. Alfalfa and pasture production account for the greatest single source of income; grains, melons, and orchards make up the balance.

The average pumping requirement has been about 32,000 acre-feet annually during the last decade.

Water Quality. The quality of the ground water in the Fremont Valley Ground Water Basin has remained essentially unchanged during the period of record. Underflow from North Muroc Subbasin of the adjoining Antelope Valley basin is rated as inferior for beneficial uses due to the fluorides and percent sodium; the character of this water is sodium bicarbonate. Four miles north of the basin boundary, ground water from



H GROUND WATER TABLE
LLEY INTO FREMONT VALLEY

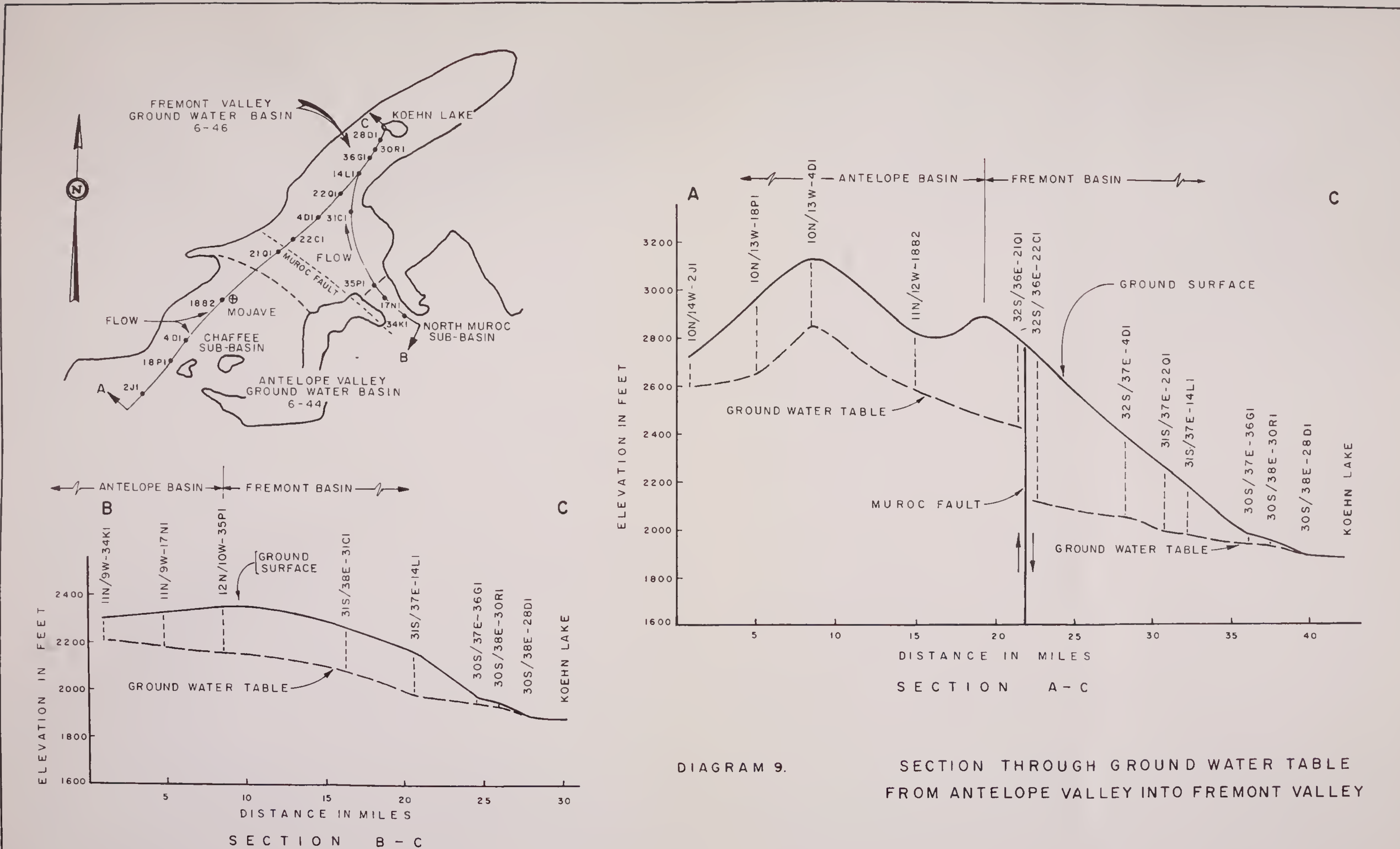


DIAGRAM 9. SECTION THROUGH GROUND WATER TABLE FROM ANTELOPE VALLEY INTO FREMONT VALLEY

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1963 wells east of California City is of a quality that is rated inferior for domestic uses, but varies from marginal to inferior for irrigation uses. Fluoride and the percent sodium content of the water are the bases for these use ratings; the sodium bicarbonate character remains the same.

Ten miles further north, waters are found of a quality considered generally suitable for domestic and irrigation uses, but with a sodium-calcium sulfate-bicarbonate character. This change in the character of the ground water is evidently caused by the uptake of sulfates which appear to emanate from the Sierra Nevada material to the west.

Between here and Koehn Lake the quality of the water varies. These variations in quality result from the comingling of underflow from many sources. At the base of the El Paso Mountains, the ground water is apparently degraded by such inflow; water from many of the wells is rated as inferior in quality for both domestic and irrigation uses.

As shown on Table 46, the wide range in the characteristics of ground water in the basin results from combinations of sodium, calcium, sulfates, bicarbonates, and the addition of chlorides. Ground waters from the periphery of Koehn Lake have concentrations of sodium and chlorides of 10,000 ppm and 14,000 ppm, respectively.

Ground water moving through the Fremont Valley basin from the south to Koehn Lake has a total dissolved solids content ranging from 400 to 700 ppm; in ground water moving from the southwest, the total dissolved solids content ranges from 800 to 1,000 ppm. In the northeast portion of the basin, ground water moving toward the lake has about 350 to 1,100 ppm total dissolved solids. The greatest concentration of total

wells east of California City is of a quality that is rated inferior for domestic uses, but varies from marginal to inferior for irrigation uses. Fluoride and the percent sodium content of the water are the bases for these use ratings; the sodium bicarbonate character remains the same.

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TABLE 46

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
FREMONT VALLEY GROUND WATER BASIN (6-46)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
East of Mojave 11N/11W-8D1	DI						Na HCO_3	1918 2-27-30 10-21-55	205 218 198	Unknown
Northeast of Mojave 32S/36E-22N1		D	I	SO_4, F	B		Na SO_4			Domestic
32S/36E-22B1		DI		SO_4, B			Ca-Na SO_4			Domestic
12N/10W-35P1			DI		F, % Na		Na HCO_3	1918 12- 3-53	199 ft 195.5ft	Unused
32S/38E-32N1			DI		F, % Na		Na HCO_3	3- 4-58	247.4ft	Unused
California City 32S/37E-24N2			DI		F, % Na		Na HCO_3-Cl	9- 4-29	238.0ft	Domestic
32S/37E-14N1		I	D	% Na	F		Na HCO_3	1-30-58	323.4ft	Irrigation
North of California City 32S/37E-4P1	DI						Na HCO_3	1-28-58	339.9ft	Irrigation
31S/37E-35N1	DI						Na Cl-SO_4	1-22-53 3- 4-58	230.8ft 243.7ft	Unused
31S/37E-26D1	I	D		SO_4			Na SO_4-HCO_3			Domestic

D - Domestic
I - Irrigation

TABLE 46

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

FREMONT VALLEY GROUND WATER BASIN (6-46)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
31S/37E-14L1	DI						Na-Ca SO_4-HCO_3	10- 1-29 1-22-53	184.5ft 196.6ft	Domestic
31S/37E-10A1	DI						Na-Ca SO_4-HCO_3	3-10-53	120 ft	Domestic Irrigation
31S/37E-5M2	DI						Na SO_4			Domestic
30S/37E-34B1			DI	SO_4	F, B, % Na		Na SO_4			Domestic
30S/37E-36C1	DI						Na-Ca HCO_3-SO_4			Unknown
Cantil 30S/37E-23J1		DI		F, B			Na-Ca Cl-HCO_3			Domestic
30S/38E-30R1	I	D		F			Ca-Na Cl	1917 1-31-58	flow 14.2ft	Unused
30S/38E-34C1		I	D	EC, TDS	SO_4		Ca SO_4			Unknown
30S/38E-19K1	I	D		F			Na HCO_3	1917 2-26-58	+4 15.6ft	Domestic Irrigation
30S/37E-12N1			DI	Cl	EC, SO_4, F, B, TDS, % Na		Na-SO_4	4-23-53 2-27-58	104.8ft 106 ft	Domestic

D - Domestic
I - Irrigation

TABLE 46

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

FREMONT VALLEY GROUND WATER BASIN (6-46)

(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
30S/38E-4D1			DI		EC, SO_4, Cl F, B, TDS, % Na		Na Cl-SO_4			Domestic
West of Koehn Lake 30S/38E-8J1			DI		EC, SO_4, Cl F, B, TDS, % Na		Na Cl			Unknown
30S/38E-21D1	I		D		F		Ca-Na HCO_3-SO_4	5-12-53 10-10-56	+0.70ft flow	Stock
29S/40E-21A1	D		I		% Na		Na HCO_3	8-24-55	396 ft	Mining
29S/39E-12L1	I	D		SO_4			Na SO_4	1917 2-13-58	460 ft 397.4ft	Industrial
Garlock 29S/39E-15M1	I		D	TDS	SO_4	1.4 $\pm$ 1.1	Mg-Na SO_4	2-13-58	63.9ft	Unused
29S/39E-29N1	DI						Na SO_4-HCO_3	2-13-58	66.8ft	Irrigation
29S/39E-33H1	DI					-1.4 $\pm$ 1.2	Na Cl	2-18-58	176.5ft	Irrigation
30S/39E-8A1		D	I	SO_4, % Na, TDS	Cl, B, EC		Na Cl	2-12-58	137.9ft	Unknown
Saltdale 29S/38E-27R1	D		I		% Na		Na Cl			Unknown

D - Domestic
I - Irrigation

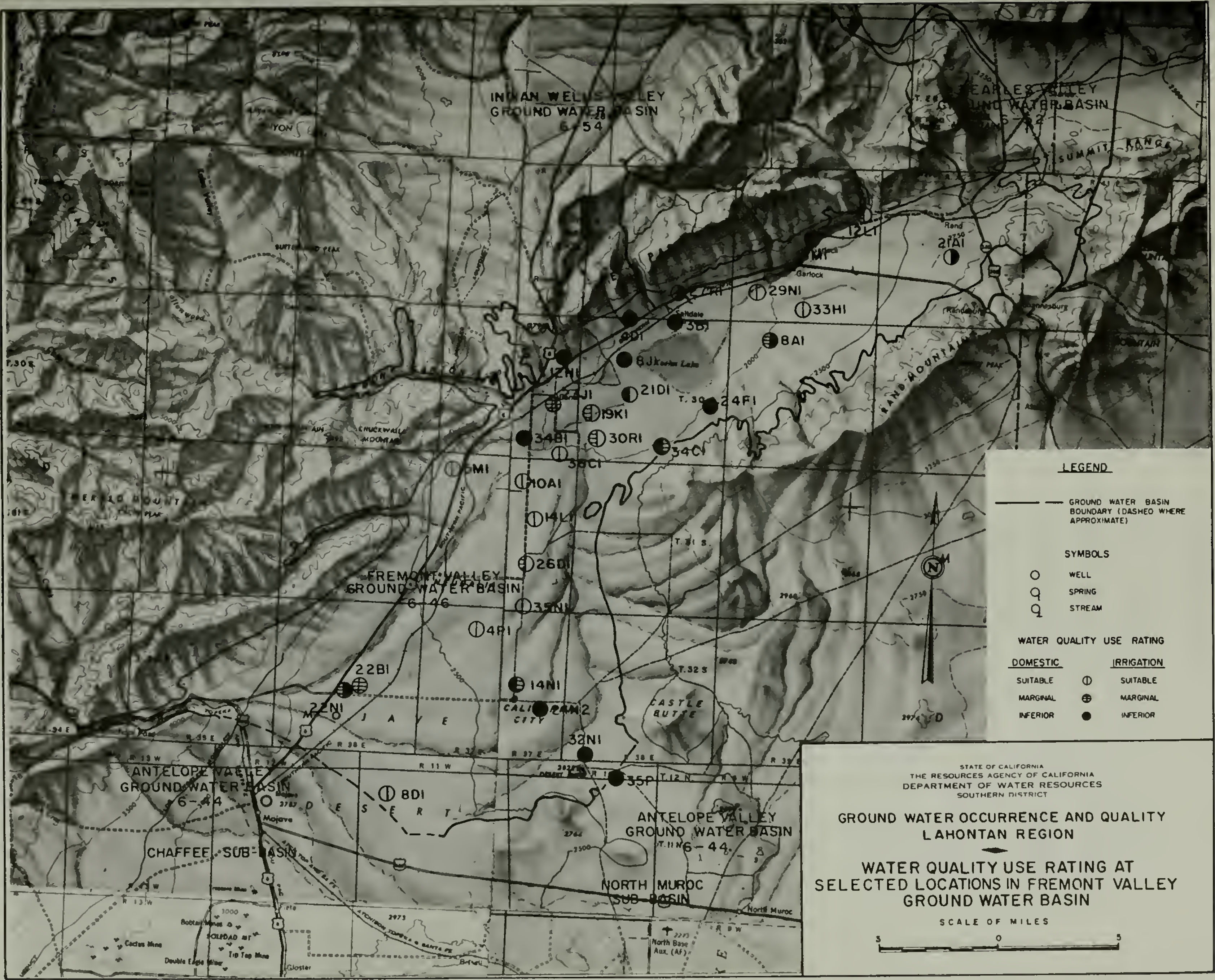
TABLE 46

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

FREMONT VALLEY GROUND WATER BASIN (6-45)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
30S/38E-3B1			DI		EC, SO_4, Cl, F, B, TDS, % Na		Na Cl	10-10-56	27.9ft	Domestic
30S/38E-24F1			DI	% Na	EC, F, B, Cl, SO_4		Na Cl	5- 7-53 2-12-58	12.2ft 13.0ft	Unused

D - Domestic
I - Irrigation


INDIAN WELLS VALLEY
GROUND WATER BASIN
6-54
SEARLES VALLEY
GROUND WATER BASIN
SUMMIT RANGE
FREMONT VALLEY
GROUND WATER BASIN
6-46
ANTELOPE VALLEY
GROUND WATER BASIN
6-44
CHAFFEE SUB-BASIN
NORTH MUROC
SUB-BASIN
CASTLE BUTTE
CALIFORNIA CITY
MOJAVE
DESERT
Mojave
Garlock
Randsburg
Rand
North Muroc
North Base Aux. (AF)
12L1
21A1
29N1
33H1
8A1
3D1
9D1
8J1
12N1
21D1
24F1
19K1
30R1
34B1
34C1
36C1
5M1
10A1
14L1
26D1
35N1
4P1
22B1
22N1
14N1
32N1
35P1
8D1
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
SUITABLE
MARGINAL
MARGINAL
INFERIOR
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN FREMONT VALLEY
GROUND WATER BASIN
SCALE OF MILES
5
0
5

Harper Valley Ground Water Basin (6-47)

Harper Valley Ground Water Basin, shown on Figure 41, is an irregularly shaped, northwesterly trending area of about 514 square miles located in the western part of San Bernardino County, within the Searles Lake Drainage Basin (No. 21).

The basin is bounded on the north by Fremont Peak, the Gravel Hills, and Black Mountain; on the east by a series of low hills, and on the south by Iron Mountain. An alluvial divide, extending from Iron Mountain to the Kramer Hills, and another, extending from these hills to the granitic highlands on the northwest, form the southern and southwestern boundary of the basin.

Maximum elevation in the surrounding highlands is attained on Fremont Peak which stands at an elevation of 4,800 feet. The lowest point in the basin is Harper Lake; this dry lake covers an area of 16 square miles, and is at an elevation of 2,020 feet.

Geology

The highlands to the north consist of pre-Tertiary granitic rocks. The Gravel Hills consist of Tertiary sediments; the Black Mountains are composed predominately of Quaternary volcanic rocks. Iron Mountain is composed of pre-Tertiary granitic and metamorphic rocks and Paleozoic sediments. On the south, an alluvial high extends between the Iron Mountain area and the Kramer Hills; these hills consist of Triassic metavolcanic rocks, pre-Tertiary granitic rocks, and Tertiary volcanic rocks and sediments.

Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 452 feet. Quaternary dune sand deposits occur along the eastern edge of Harper Lake, a compound type of playa. A pressure area exists in the vicinity of this dry lake. The northwesterly trending Lockhart fault, flanked by isolated granitic hills, acts as a barrier to ground water movement in the basin.

Water Supply

The source of ground water replenishment in the basin is deep percolation of rainfall and streamflow from the watershed. The annual rainfall on the valley is approximately four inches. The basin area has no surface inflow other than occasional flood runoff from Grass Valley through Black Canyon. Recharge to the valley occurs in the alluvial fans which fringe the basin. Usable ground water supplies are derived from the Recent and underlying older alluvial deposits.

Harper Valley basin receives subsurface inflow of ground water from the Middle Mojave River Valley basin; much of this inflow enters through the area surrounding Red Hill. The movement of the ground water results from a hydraulic gradient which slopes from Middle Mojave River Valley basin into Harper Valley basin, at a gradient of about 15 feet per mile, as shown on Diagram 7. From well 10N/3W-10R1, which is in the Middle Mojave River Valley basin, to well 10N/3W-4H1 in Harper Valley basin, the gradient increases to about 25 feet per mile. This change in gradient gives evidence of a partial ground water barrier which serves to delineate the basin boundary. Beyond this boundary, the gradient again decreases; it is about 11 feet per mile toward the Lockhart Ranch area southwest of Harper Lake.

Ground water normally flows towards the Lockhart Ranch area but as a result of heavy pumping, a ground water depression has developed. This depression was most prominent in 1954-57 when 2,300 acres were being irrigated. In July 1961, only about 500 acres were being irrigated, and the pumping depression, though still in existence, had greatly diminished.

A small quantity of subsurface flow possibly enters the valley from Cuddeback Valley Ground Water Basin.

Development and Utilization. The population of the basin has slowly increased from less than 50 in 1920 to about 500 in 1961. This increase was largely due to an increase in irrigated agriculture at Lockhart. The centers of population are the Lockhart area and Kramer Junction.

In 1920 there were approximately 50 wells in the valley; at present there are about 160 wells. Most of these wells are in the Lockhart area and are utilized for irrigation purposes.

In the period 1954-1957, the Lockhart Ranch irrigated 2,300 acres of alfalfa and some oats. At this time there was also a number of chichen farms in this area. The Lockhart Ranch has now decreased its productive area to about 500 acres. During the period of greatest production in the valley, about 12,000 acre-feet of ground water was being extracted annually; this has now decreased to approximately 3,500 acre-feet per year. Water levels at Black's Ranch have remained at the surface since 1917, but the levels in the Lockhart area have dropped about 30 feet since 1919.

Water Quality. The water quality of Harper Valley has remained fairly constant during the 40 years of record. The quality of subsurface inflow from Middle Mojave River Valley Ground Water Basin is suitable but becomes marginal to inferior as the water moves toward Harper Lake. The water quality in the western part of the valley, at well 10N/6W-5E3, is rated as inferior for irrigation uses because it has a high percent sodium (85 percent) and a boron concentration of 3.0 ppm. The fluoride concentration and the percent sodium are the basis for rating the quality of the water from wells in the northern part of the valley marginal to inferior.

The total dissolved solids content of ground water entering the basin through the narrows at Red Hill is about 300 to 400 ppm. By the time ground water reaches the Lockhart area the total solids content is in the 800 to 900 ppm range and is as high as 2,391 ppm along the western edge of the dry lake. Ground water moving from the west side of the basin is higher in total dissolved solids, as indicated by samples from Kramer Junction which ranges from 1,350 to 1,650 ppm.

Throughout the basin, the concentrations of boron and fluoride, and the high percent sodium are the basis for rating the quality of the water marginal to inferior as shown on Table 47. The boron concentration ranges from 0.26 to 3.38 ppm, and averages about 1.76 ppm. Fluoride concentrations range from 0.5 to 3.0 ppm, but are generally less than 1.5 ppm. The percent sodium ranges from 72.4 to 91.3 percent and averages 81.9 percent.

Subsurface inflow from the Middle Mojave River Valley basin generally has a sodium chloride-bicarbonate character; as the inflow moves under the dry lake, however, chloride replaces bicarbonate as the predominant anion. The sodium chloride character of the ground water in the area southwest of the dry lake results from subsurface inflow of these chloride waters from Middle Mojave Valley basin plus the resolution of evaporate deposits within the sediments underlying the dry lake. Ground water in the western and northern parts of the basin has a sodium chloride-sulfate character.

TABLE 47

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

HARPER VALLEY GROUND WATER BASIN (6-47)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Harper Lake 11N/4W-4R2		D	I	EC, Cl, F, TDS	B, % Na		Na Cl	7-25-61	64.0 ft.	Irrigation
11N/3W-7D1			DI		F, B, % Na	35.9 ± 2.2	Na HCO_3-Cl	7-25-61	64.0 ft.	Unknown
11N/4W-19H1			DI	% Na	EC, Cl, TDS		Na Cl	10-30-50 6-10-53 11-11-59 3-23-60	76.7 ft. 108.5 ft. 86.5 ft. 81.2 ft.	Domestic Stock
11N/5W-24G1		D	I	F	% Na		Na Cl-HCO_3			Domestic Irrigation
11N/4W-30N2	D		I	B, EC	% Na	2.7 ± 1.3	Na Cl-SO_4	6-12-53	158.9 ft.	Irrigation
11N/4W-32L1		DI		F, % Na			Na Cl-SO_4			Domestic Stock
11N/4W-33G1		D	I	F	% Na	28.0 ± 2.0	Na Cl			Domestic Irrigation Stock
10N/4W-8P1		D	I	F	% Na		Na Cl	6-15-53	110 ft	Domestic
10N/4W-3F1		D	I	SO_4, B, EC	Cl, TDS		Na Cl	3-5-55 11-11-59 3-23-60	147.2 ft 168.4 ft. 166.7 ft.	Unknown
11N/3W-30K1	D		I		% Na	4.7 ± 0.8	Na HCO_3			Irrigation

D - Domestic
I - Irrigation

TABLE 47

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

HARPER VALLEY GROUND WATER BASIN (6-47)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Harper Lake (cont.)										
11N/3W-28L1		D	I	F	% Na		Na HCO_3			Domestic
11N/3W-33H1	D	I		% Na		6.5 ± 0.9	Na HCO_3			Irrigation
Kramer Junction										
10N/6W-5E3		D	I	SO_4, F, TDS	% Na, B	5.8 ± 1.2	Na Cl-SO_4	3-29-56 5-2-57 3-23-60	198.0 ft 250.0 ft 200.5 ft	Domestic
11N/6W-32Z1			DI	Cl, F, TDS	SO_4, B, % Na		Na Cl			Unknown
McDonalds Ranch										
32S/43E-28K1		D	I	SO_4, F, B	% Na	37.5 ± 2.2	Na SO_4	6-17-53 7-25-61	11 ft 13.0 ft	Unknown
Hinkley										
10N/3W-4H1	DI					5.2 ± 0.9	Na-Ca HCO_3-Cl	7-24-61	56.7 ft	Domestic
10N/3W-10R1	DI						Na HCO_3	1-21-54 3-2-60	26.3 ft 51.5 ft	Unknown
10N/3W-15Q1	DI						Na HCO_3	12-14-53 1-8-59	47 ft 56 ft	Domestic Irrigation
10N/3W-24E1	DI						Na HCO_3	7-6-32 1-9-59	34 ft 60 ft	Domestic
10N/2W-30R1	DI						Ca-Na HCO_3	7-6-32	17 ft 29 ft	Domestic

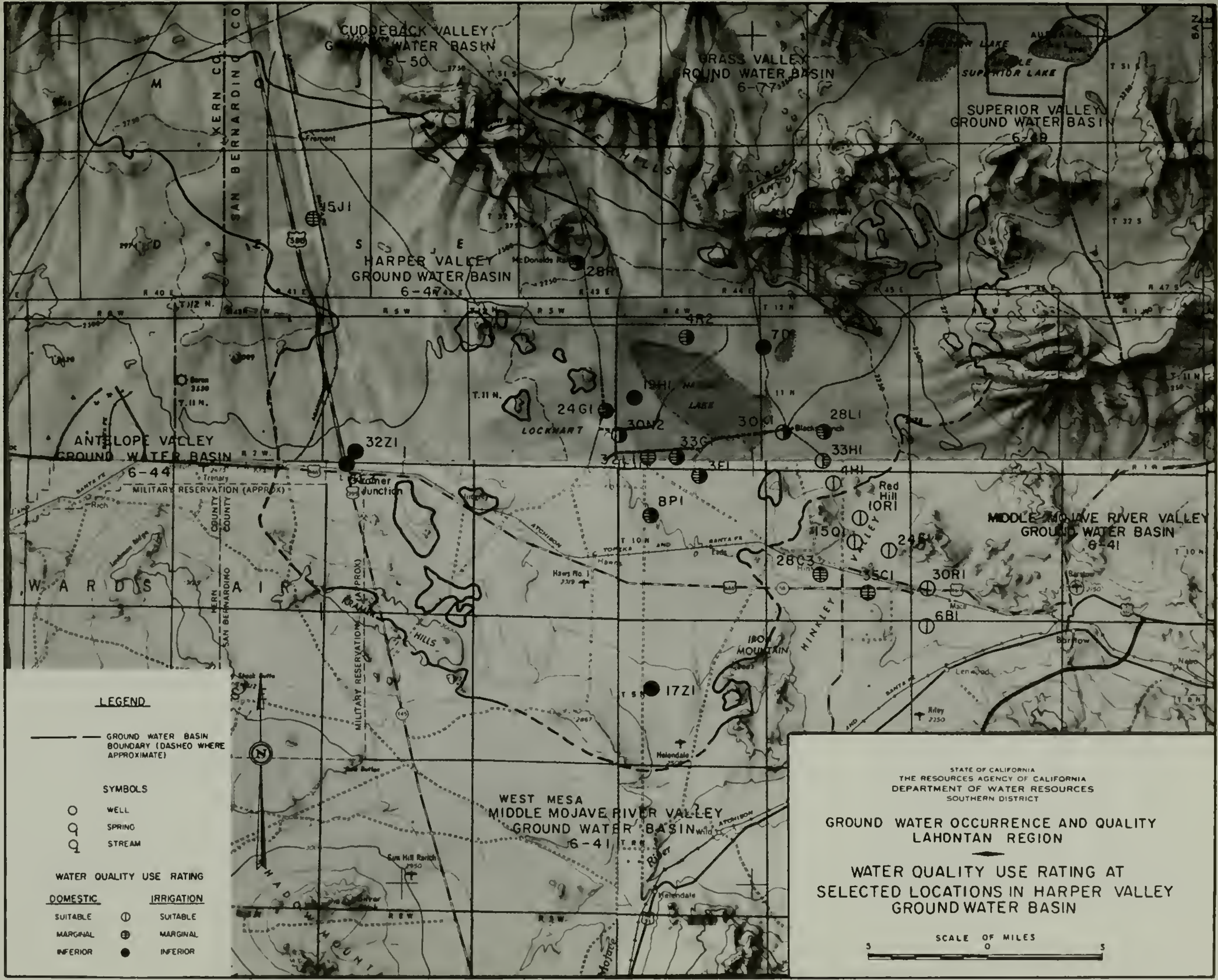
D - Domestic
I - Irrigation

TABLE 47

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
HARPER VALLEY GROUND WATER BASIN (6-47)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Hinkley (cont.) 9N/2W-6B1	DI						Na-Ca HCO_3	1-14-57	34 ft	Irrigation
10N/3W-35C1		DI		SO_4, TDS, EC		2.0 $\pm$ 1.7	Ca-Na Cl-SO_4	5-29-59	55 ft.	Irrigation
10N/3W-28C3		DI		F, % Na		17.7 $\pm$ 1.9	Na HCO_3-SO_4	7-24-61	44.2 ft	Domestic
Southern 9N/4W-17Z1			DI	Cl, F	SO_4, B, TDS		Ca-Na SO_4			Unknown
Northwestern 32S/41E-15J1		DI		F, % Na, B			Na HCO_3-SO_4			Unknown

D - Domestic
I - Irrigation


CUDDEBACK VALLEY GROUND WATER BASIN 6-50
GRASS VALLEY GROUND WATER BASIN 6-77
SUPERIOR VALLEY GROUND WATER BASIN 6-48
SUPERIOR LAKE
HARPER VALLEY GROUND WATER BASIN 6-47
ANTELOPE VALLEY GROUND WATER BASIN 6-44
MIDDLE MOJAVE RIVER VALLEY GROUND WATER BASIN 6-41
WEST MESA MIDDLE MOJAVE RIVER VALLEY GROUND WATER BASIN 6-41
KERN CO
SAN BERNARDINO CO
MILITARY RESERVATION (APPROX)
LOCKHART
Kramer Junction
Red Hill
IRON MOUNTAIN
HINKLEY VALLEY
Barstow
Helendale
Hawes No. 1
McDonalds Ranch
15J1
28R1
4R2
7D1
19H1
24G1
30N2
30K1
28L1
33G1
33H1
3F1
4H1
32Z1
8P1
10R1
15Q1
24E1
28C3
35C1
30R1
6B1
17Z1
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
MARGINAL
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT SELECTED LOCATIONS IN HARPER VALLEY GROUND WATER BASIN
SCALE OF MILES
5 0 5

Goldstone Valley Ground Water Basin (6-48)

Goldstone Valley Ground Water Basin, shown on Figure 42, is a long narrow northerly trending area of about 27 square miles, located in the northwest part of San Bernardino County, within the Searles Lake Drainage Basin (No. 21).

Low hills, rising about 600 feet above the valley floor, border the basin on all sides. The lowest point in the valley, Goldstone Lake, stands at an elevation of 3,055 feet, and is 1.75 square miles in area.

Geology

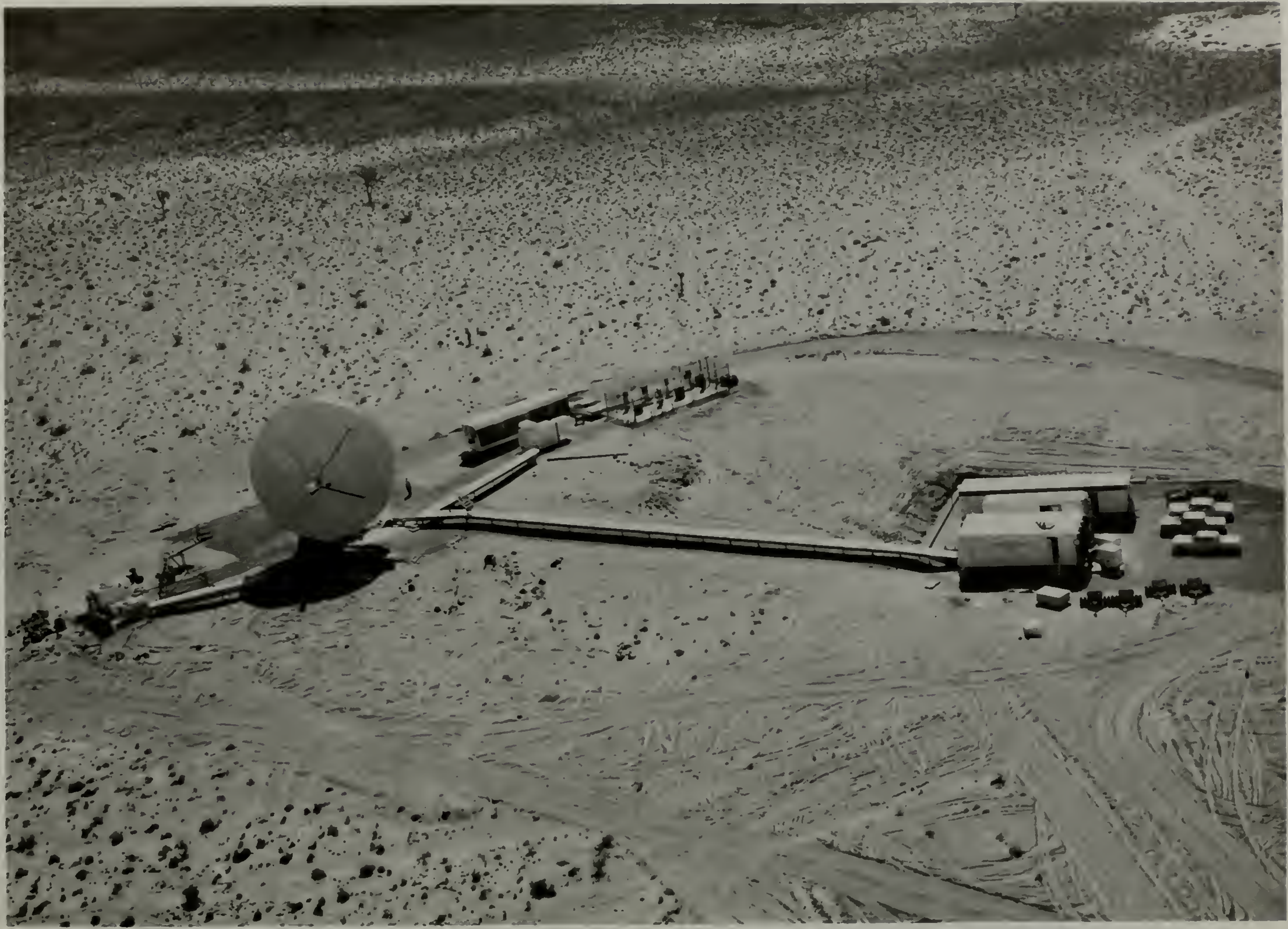
The hills which surround the basin on the northwest, north, and east consist of Tertiary volcanic rocks, those to the southeast consist of pre-Tertiary granitic rocks. Paleozoic sediments occur in the hills to the south and in the Goldstone Hills along the southwestern margin of the basin.

Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 330 feet. Goldstone Lake is a dry type of playa.

Water Supply

The principal source of ground water replenishment in Goldstone Valley Ground Water Basin is percolation of streamflow originating in the watershed. The annual rainfall in the basin area is probably less than three inches; the surface inflow to the valley is quite limited. Alluvial fans fringing the basin serve as recharge areas.

Ground water in the Recent and underlying older alluvium flows centripetally toward Goldstone Lake. There is no subsurface inflow of ground water. South of Goldstone Lake, well 14N/1E-7B1 was drilled in connection with a Camp Irwin water supply survey. The depth to water in this well is 230 feet.



Goldstone Tracking Station

National Aeronautics and Space Administration—Western Operations Office

A tracking station near the dry lake is used for satellite communication.

Development and Utilization. The valley has had no domestic development during the period of historic record which began in 1917. The northern half of the valley lies in the Camp Irwin Military Reservation. At present, a tracking station at the southern end of the dry lake is used for satellite communication.

Water Quality. An analysis of water from well 14N/1E-7B1 indicates the water was of calcium-sodium chloride character, with a chloride content of 613 ppm. Because of this high content the water was rated as inferior in quality for irrigation uses. Since the water also had a fluoride content of 1.0 ppm and a total dissolved solids content of 1,818 ppm, it was rated as marginal in quality for domestic uses, as shown on Table 48.

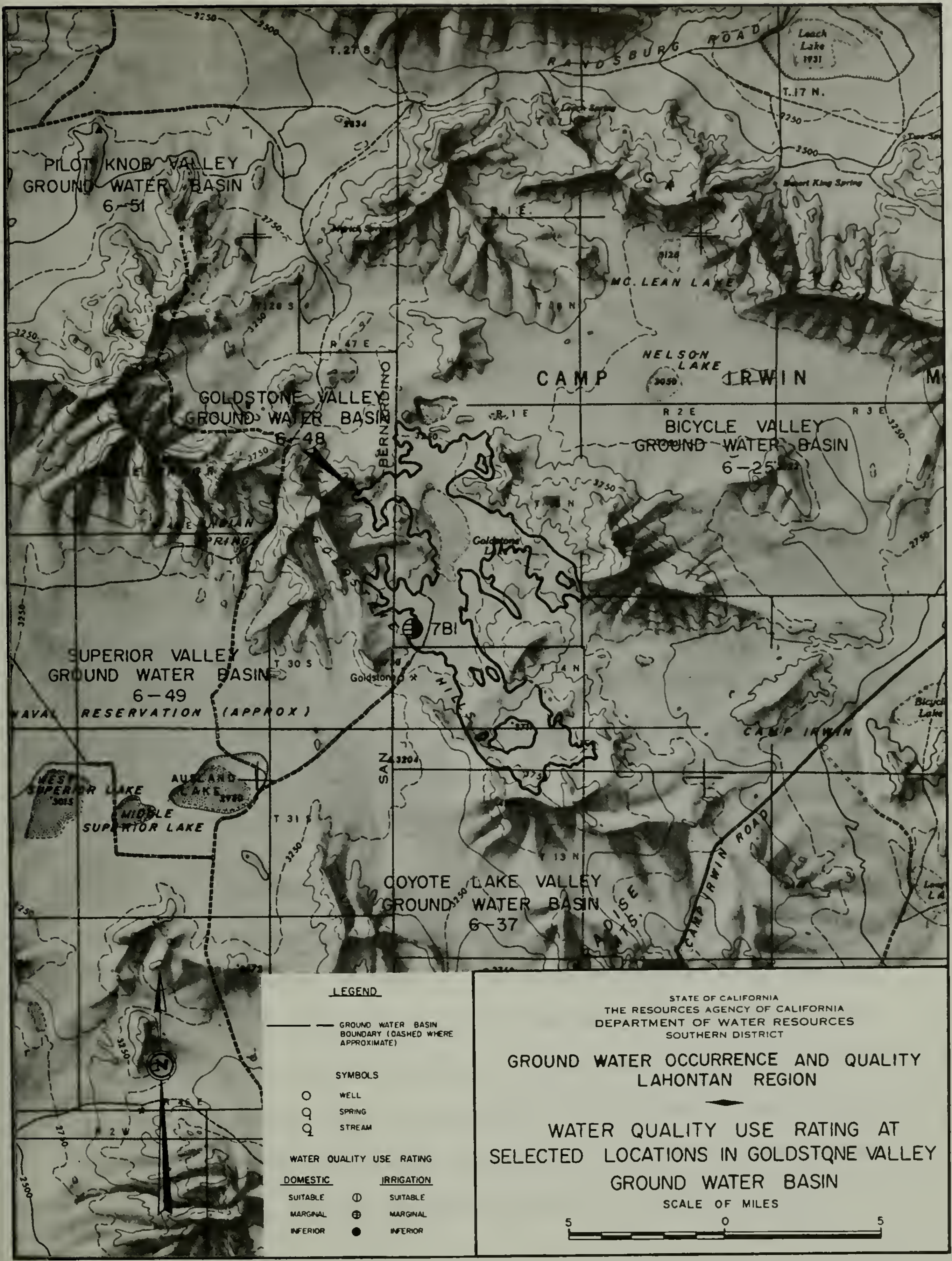
TABLE 48

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
GOLDSTONE VALLEY GROUND WATER BASIN (6-48)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification			Water Quality Use Rating: Basis for Classification		Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
South of dry lake 14N/1E-7B1		D	I	F, TDS	Cl		Ca-Na Cl	6-20-43	230 ft	Test

D - Domestic
I - Irrigation

FIGURE 42



RANDSBURG ROAD
Leach Lake 1931
T. 27 S.
T. 17 N.
PILOT KNOB VALLEY
GROUND WATER BASIN
6-51
MC. LEAN LAKE
NELSON LAKE
CAMP IRWIN
GOLDSTONE VALLEY
GROUND WATER BASIN
6-48
BICYCLE VALLEY
GROUND WATER BASIN
6-25
SAN BERNARDINO
781
Goldstone
SUPERIOR VALLEY
GROUND WATER BASIN
6-49
NAVAL RESERVATION (APPROX)
WEST SUPERIOR LAKE
MIDDLE SUPERIOR LAKE
CAMP IRWIN ROAD
COYOTE LAKE VALLEY
GROUND WATER BASIN
6-37
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
MARGINAL
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN GOLDSTONE VALLEY
GROUND WATER BASIN
SCALE OF MILES
5
0
5

Superior Valley Ground Water Basin (6-49)

Superior Valley Ground Water Basin, shown on Figure 43, is a roughly elliptical-shaped northwesterly trending area of about 172 square miles, located in the northwestern part of San Bernardino County, within the Searles Lake Drainage Basin (No. 21).

The basin is bounded on the north by Robber Mountain and the Eagle Crags, and on the northeast by the Goldstone Hills. Opal Mountain is on the south, and Slocum Mountain and Pilot Knob on the west.

The highest point in the surrounding highlands is Eagle Crags which rises to an elevation of 5,500 feet. The valley floor slopes from the surrounding mountains toward three dry lakes which are arranged in an almost east-west direction near the south central part of the basin: West Superior Lake which is 3.1 square miles in extent, Middle Superior Lake covering an area of 0.7 square miles, and Ausland Lake which includes an area of 2.6 square miles. Ausland Lake is the lowest point in the basin, at an elevation of 2,996 feet.

Geology

Tertiary volcanic rocks occur to the north in Robber Mountain and Eagle Crags, and to the northeast in the Goldstone Hills. The hills also contain Paleozoic sediments. Pre-Tertiary granitic rocks occur in the mountains and hills to the east and southeast. To the south, pre-Tertiary granitic, Tertiary volcanic, and Quaternary volcanic rocks occur in the Opal Mountain area. Rocks similar to those found along the southern edge of the basin also occur to the west in the Slocum Mountain and Pilot Knob areas, however, pre-Tertiary granitic rocks predominate.

Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 368 feet. Ausland, Middle Superior, and West Superior Lakes are all dry types of playa.

Water Supply

The sources of ground water replenishment on the basin are deep penetration of direct precipitation and percolation of streamflow originating in the watershed. Annual rainfall in the valley is approximately six inches; surface inflow is limited to occasional runoff from the surrounding mountains. Water entering the alluvial fans fringing the highland areas recharges the basin at a moderate rate. Ground water in the Recent and underlying older alluvium moves radially toward Ausland Lake. Water levels have remained almost constant throughout the period of record which began in 1920.

A northerly extending ground water barrier occurs near the eastern edge of the basin. Water levels east of this barrier are about 55 feet lower than water levels to the west of this feature.

Development and Utilization. The population of this valley was reported to be over 100 during the period 1917-1920, but at present there is no one living in the valley. During this earlier period, twenty wells were in operation, but at present there are 28 wells, most of which are located near the playas. There are a few stock wells in the northwestern part of the basin which are used only during the winter months. The total extraction for the valley is probably less than two acre-feet per year.

Water Quality. The quality of the ground water in the basin has been marginal to inferior for both domestic and irrigational uses throughout the period of record, which began in 1953. As shown on Table 49, a high percent of sodium and fluoride content are the major constituents forming the basis for this rating. Most of the ground water in the basin has a sodium bicarbonate character.

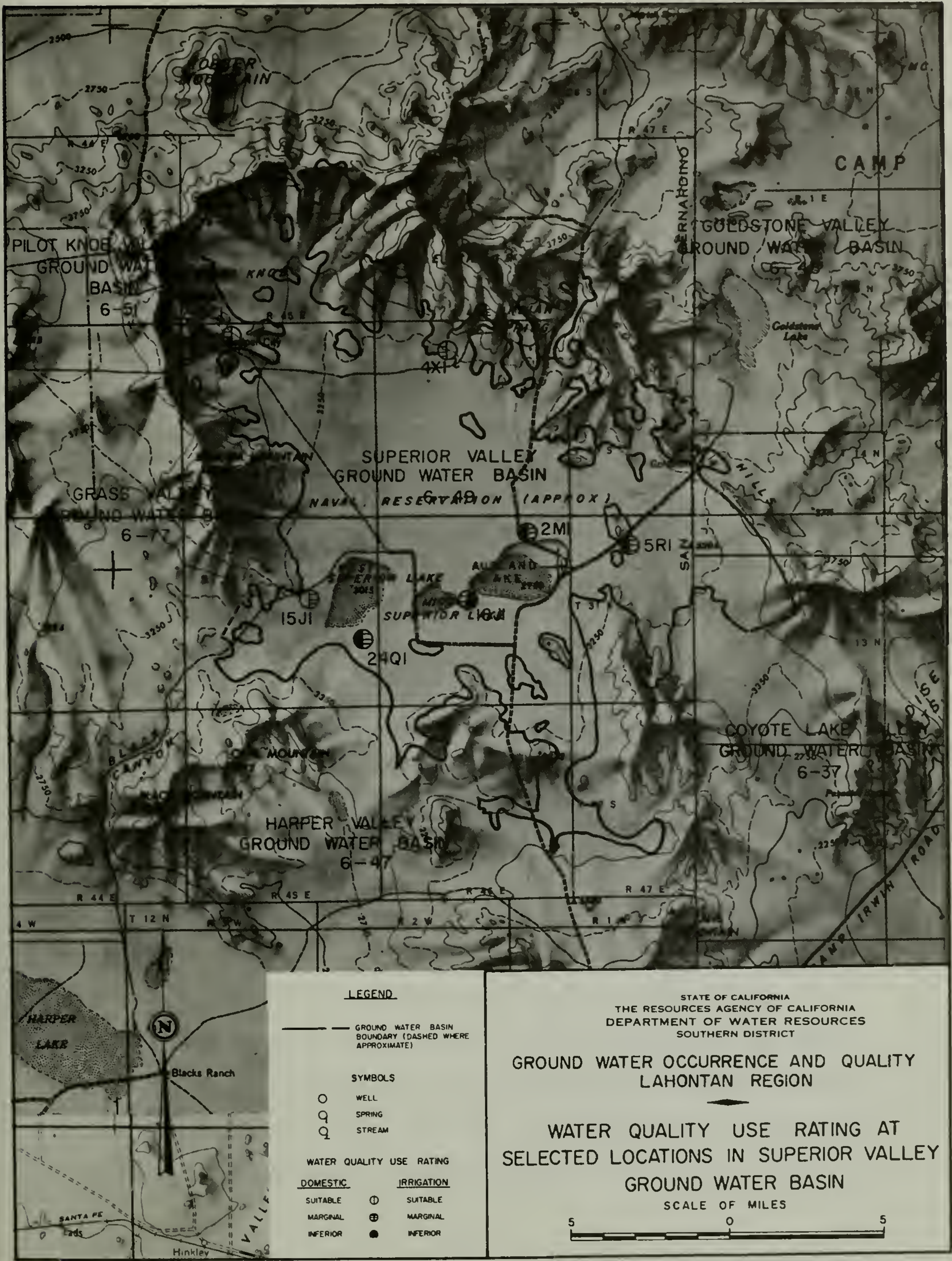
Fluoride ion concentration range from 0.1 to 4.0 ppm; they average 1.7 ppm. The percent sodium averages 73 percent. The total dissolved solids content ranges from 357 to 2,265 ppm; the mean is about 605 ppm.

TABLE 49

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
SUPERIOR VALLEY GROUND WATER BASIN (6-49)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
Northern 30S/46E-4X1	I	D		F			Ca-Na HCO_3	9-22-17	flow	Unknown
30S/45E-5Z1	I	D		SO_4, TDS			Na HCO_3	1-10-18	flow	Unknown
Western 31S/45E-15J1	D	I		% Na		16.3 $\pm$ 1.8	Na HCO_3	1920 8-25-53 7-26-61	115 ft 107.6 ft 108.0 ft	Unknown
31S/45E-24Q1		I	D	% Na	F	1.3 $\pm$ 0.6	Na HCO_3-Cl	8-25-53 12- 1-54 7-26-61	106.6 ft 105.9 ft 108.2 ft	Stock
Central 31S/46E-16J1		D	I	EC, F, TDS	Cl	3.8 $\pm$ 1.0 9.9 $\pm$ 1.7	Na-Ca Cl	12- 1-54 11-17-59 7-26-61	109.1 ft 99.8ft 93.2ft	Unknown
31S/46E-2M1		I	D	% Na	F	9.6 $\pm$ 1.6	Na HCO_3	1920 2-10-54 7-26-61	105 ft 101.7ft 101.7ft	Unknown
Eastern 31S/47E-5R1		I	D	% Na	F		Na SO_4-Cl	1920 2-10-54 12- 1-54	249 ft 252.5ft 252.9ft	Unknown

D - Domestic
I - Irrigation


PILOT KNOB VALLEY
GROUND WATER
BASIN
6-51
SUPERIOR VALLEY
GROUND WATER BASIN
6-49
NAVAL RESERVATION (APPROX)
GRASS VALLEY
GROUND WATER BASIN
6-77
GOLDSTONE VALLEY
GROUND WATER BASIN
CAMP
Goldstone Lake
COYOTE LAKE VALLEY
GROUND WATER BASIN
6-37
HARPER VALLEY
GROUND WATER BASIN
6-47
4X1
2M1
5R1
15J1
24Q1
SUPERIOR LAKE
CAMP IRWIN ROAD
HARPER LAKE
Blacks Ranch
SANTA FE
Hinkley
R 44 E
R 45 E
R 47 E
T 12 N
R 1 W
R 2 W
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
MARGINAL
INFERIOR
SUITABLE
MARGINAL
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN SUPERIOR VALLEY
GROUND WATER BASIN
SCALE OF MILES
5
0
5

Cuddeback Valley Ground Water Basin (6-50)

Cuddeback Valley Ground Water Basin, shown on Figure 44, is an irregularly shaped area of about 130 square miles located in the western part of San Bernardino County, within the Searles Lake Drainage Basin (No. 21).

Cuddeback basin is bounded on the north by the Lava Mountains, on the east by a series of hills, on the south by Fremont Peak and the Gravel Hills, and on the west by the Rand Mountains.

Red Mountain, the highest peak in the surrounding highlands, rises to an elevation of 5,270 feet. The elevation of the valley floor is about 2,800 feet, and the lowest point in the basin is Cuddeback Lake which stands at an elevation of 2,553 feet; this dry lake includes an area of 6.3 square miles.

Geology

The Lava Mountains, along the northern edge of the basin consist predominately of Tertiary volcanic rocks. An alluvial high to the northeast joins the Lava Mountains to highlands on the east. These highlands consist of pre-Tertiary granitic rocks and some Tertiary volcanic rocks. To the south, the Gravel Hills consist of Tertiary sediments; Fremont Peak and its westerly extension consist of pre-Tertiary granitic rocks. The Rand Mountains to the west consist primarily of Precambrian metamorphic rocks with some pre-Tertiary granitic and Tertiary volcanic rocks.

The Quaternary alluvium covers the major portion of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 300 feet. A pressure area exists in the vicinity of Cuddeback Lake, a dry type of playa.

Water Supply

The principal source of ground water replenishment in Cuddeback Valley Ground Water Basin is percolation of streamflow originating in the watershed. The annual rainfall in the basin area is approximately 5 inches. Surface inflow is limited to occasional flood runoff from the surrounding mountains. The main areas of recharge are the fans of the Red Mountain and Fremont Peak.

Ground water, which is found in Recent and underlying older alluvium, moves toward Cuddeback Lake from the mountains on the west and east. There is also a possibility of subsurface outflow from Cuddeback Valley basin towards Harper Valley basin through the gap between Fremont Peak and the Gravel Hills. The hydraulic gradient from the wells in the north central and western area of the valley to the southern end of the dry lake, is approximately 1 foot per mile. Since the gradient is toward the southern end of the dry lake, and Harper Valley is about 500 feet below Cuddeback basin, there is a possibility of subsurface outflow towards Harper Lake.

The water levels of the wells in the basin have changed very little during the period of record which began in 1917. The depth to water near the dry lake is about 60 feet, whereas the depth to water 3 miles southwest of the dry lake at well (30S/41E-36G1) is 236 feet. The depth to water at the Blackwater Well, a developed spring in the northeastern part of the valley, is about 20 feet. At one time this well was used as a watering station for the "Twenty Mule Teams" hauling borax from Death Valley to Mojave.

Development and Utilization. The major development in the basin area has been the sporadic mining operations in the Atolia district. Tungsten was first mined in 1904; since then, some gold and silver have also been taken out of the district. The wartime boom prices in 1916 brought thousands of miners into the Atolia district to mine the tungsten deposits, but most of the time fewer than 200 men were operating these mines. The lack of a good supply of water hindered mining and for a number of years, water was hauled in tank cars from Hinkley. In 1915, the Atolia Mine Company piped water 5 miles from a well near Randsburg to their concentration mill at Atolia. Later, water was piped from some wells west of the dry lake to the mining operations in Atolia. Presently, the Atolia mining operations are not functioning.

The only activity in the basin is at the United States Air Force bombing range which is east of Cuddeback Lake. There are approximately 30 military personnel stationed at this range. At present, the population for the entire basin area is estimated to be 50.

There are about 30 wells in the valley, most of which are located north of the dry lake. None of these wells provide water for irrigation, but a few produce water for stock during the winter months. The main use of the ground water is for domestic use by personnel at the bombing range. It is estimated that the present extraction of ground water from the basin is less than 10 acre-feet per year.

Water Quality. Historic water quality data indicate that since 1917 the ground water quality has been marginal to inferior for most beneficial uses. As shown on Figure 44 and Table 50, the water in the northwestern part of the basin is of inferior quality due to the high chloride concentration and the high total dissolved solids content.

The chloride ion in the basin concentration ranges from 60 to 2,563 ppm and the highest concentrations are found in the area northwest of Cuddeback Lake. The total dissolved solids content varies from 375 to 4,734 ppm.

The general character of the ground water in this basin is sodium chloride-bicarbonate or sodium chloride.

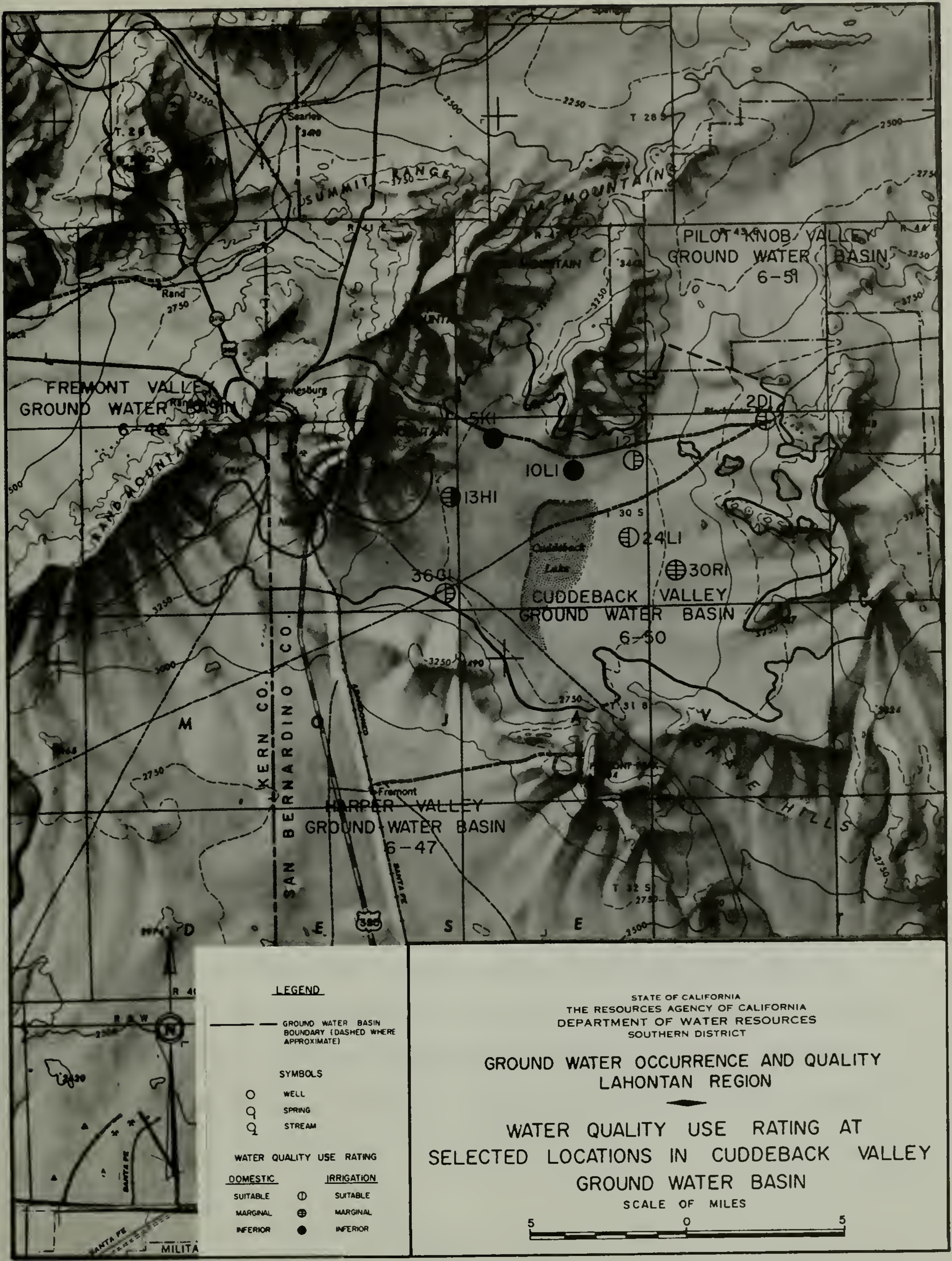
TABLE 50

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
CUDDEBACK VALLEY GROUND WATER BASIN (6-50)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
Western 30S/43E-30R1		DI		F, % Na		1.4 ± 0.7	Na HCO_3-Cl			Domestic
30S/42E-24L1	I	D		F		1.0 ± 1.2	Na-Ca Cl-HCO_3	8-19-53 12- 3-54 3-20-56	147.1 ft 147.1 ft 147.2 ft	Stock
30S/42E-12F1	D	I		% Na			Na Cl	4-29-53 12- 3-54	182.3 ft 181.7 ft	Stock
Northern 30S/42E-10L1			DI	B	TDS EC, Cl, % Na		Na Cl	4-29-53 12- 3-54 4- 9-56	70.5 ft 70.6 ft 70 ft	Stock
30S/42E-5K1			DI	% Na	EC, Cl, TDS		Na Cl	4-23-53 12- 3-54 4- 9-56	122.4 ft 122.5 ft 123 ft	Unknown
Eastern 30S/41E-13H1		D	I	% Na, TDS	EC, Cl		Na Cl	12- 2-54 7-10-56	146.3 ft 155 ft	Unknown
30S/41E-36G1	D	I		% Na			Na Cl-HCO_3	2-17-53 12- 3-54	235.3 ft 236.1 ft	Stock
Northeastern 30S/43E-2D1	I	D		F			Na HCO_3	10- 5-17 1-24-20 3- 5-55	31.6 ft 20.9 ft 19.6 ft	Unknown

D - Domestic
I - Irrigation

FIGURE 44



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SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN CUDDEBACK VALLEY GROUND WATER BASIN

SCALE OF MILES

5 0 5

Pilot Knob Valley Ground Water Basin (6-51)

Pilot Knob Valley Ground Water Basin, shown on Figure 45, is a northeasterly trending, long, narrow, and irregularly shaped area located in the northwestern part of San Bernardino County, within the Searles Lake Drainage Basin (No. 21).

The basin is bordered on the north by the Slate Range and Quail Mountains. A number of mountain peaks, including Eagle Grags, Robber Mountain, and Pilot Knob, adjoin the eastern and southern boundary; the Lava Mountains are on the western border of the basin. Mountains on both the north and south sides of the basin reach elevations of 5,500 feet; the elevation of the basin floor ranges from 3,500 to 2,250 feet.

Geology

The northern edge of the basin is defined by the Garlock fault along the base of the Slate Range and Quail Mountains. These highlands consist of pre-Tertiary granitic and metamorphic rocks with some Tertiary volcanic rocks and Tertiary-Quaternary sediments. The mountains and hills to the east consist of pre-Tertiary granitic and Tertiary volcanic rocks. Pre-Tertiary granitic rocks in Slocum Mountain, and Tertiary volcanic rocks, in the Eagle Crags, occur along the southern edge of the basin. The Blackwater fault roughly delineates the southwestern edge of the basin, which consists of pre-Tertiary granitic rocks and Tertiary and Quaternary volcanic rocks. The Lava Mountains to the west consist of Tertiary volcanic rocks and sediments. Tertiary-Quaternary sediments occur to the northwest between the Lava Mountains and Slate Range, roughly parallel to the Garlock fault.

The Quaternary alluvium which is exposed over most of the basin floor comprises the upper portion of the valley fill. The Garlock fault zone probably acts as a barrier to the movement of ground water.

Water Supply

The principal source of ground water replenishment in the basin is percolation of streamflow originating in the watershed. The annual rainfall in the basin is estimated to be about five inches. Surface flow in the basin occurs from the occasional runoff from the surrounding mountains. The major recharge areas, which have a moderate recharge capacity, are the alluvial fans that fringe the basin.

Surface flow in the eastern part of the basin drains northward toward the pass leading into the Brown Mountain Valley basin; in the western part, surface flow drains northward toward a wash leading into Searles Valley basin. Ground water may also move through these same passages into Brown Mountain and Searles Valleys. Usable ground water supplies can probably be derived from the Recent and underlying older alluvial deposits.

Development and Utilization. Although part of a naval reservation, the basin has had no significant development, and only one well is known to have existed. Well 29S/44E-22K1, a developed spring, is known as Granite Wells, and has been the most prominent watering point in the area. In 1918, this well yielded water at a rate of about 1/8 gpm, characteristic of the flow of the seeps and springs that exist in the southwestern part of the valley. Water from this well has been used for domestic or stockwatering purposes. Presently, there is no known ground water usage in the basin.

Water Quality. An analysis of water from Granite Wells in 1918, indicated that the water had a total dissolved solids content of 404 ppm; the fluoride and boron components were not reported. As shown on Table 51, the general character of this water was calcium bicarbonate.

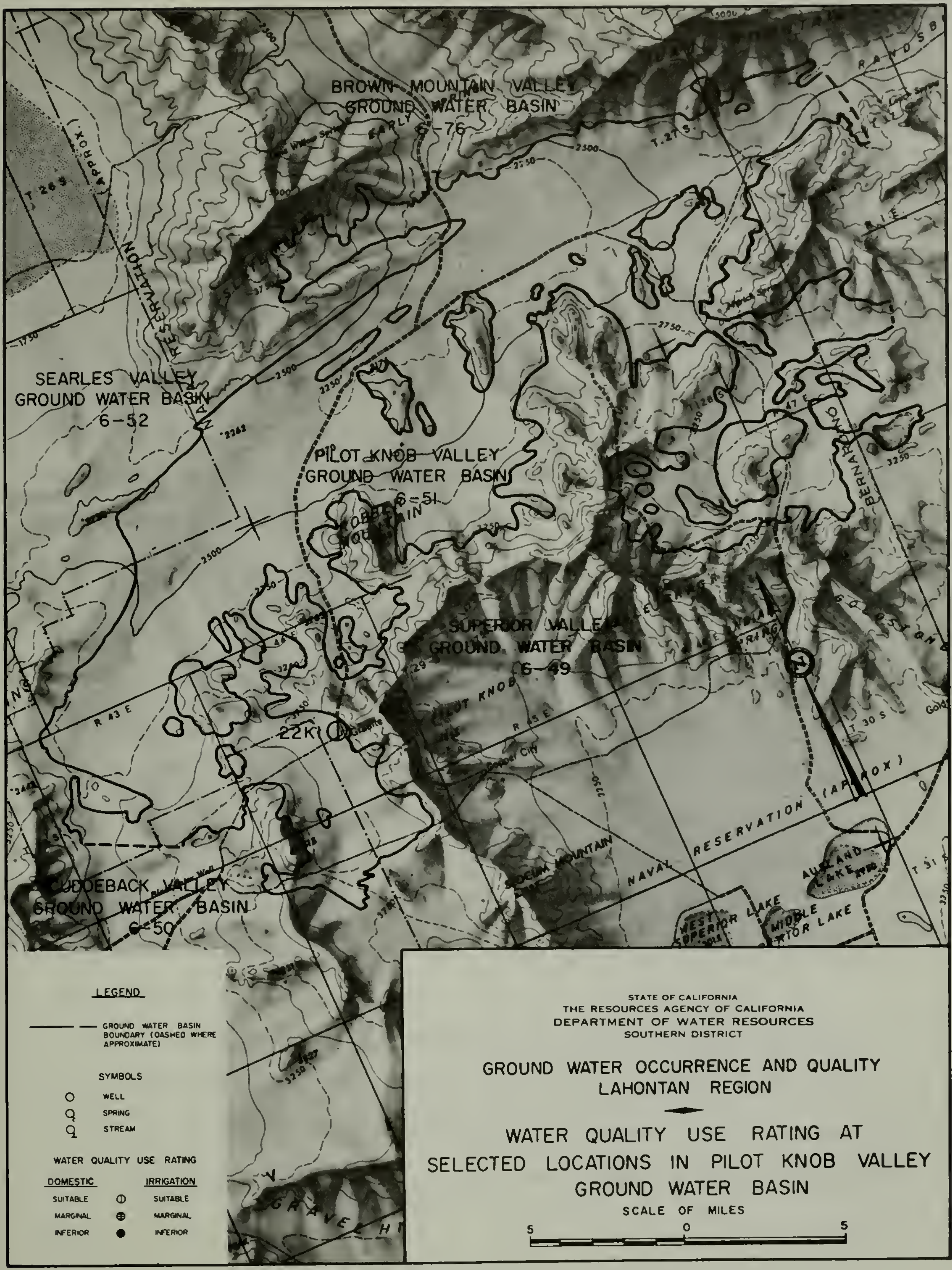
TABLE 51

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

PILOT KNOB VALLEY GROUND WATER BASIN (6-51)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
S. part of valley* 29/44E-22K1	DI						Ca HCO_3	1918	flow	Unknown
*No boron or fluoride reported										

D - Domestic
I - Irrigation



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SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN PILOT KNOB VALLEY GROUND WATER BASIN

SCALE OF MILES

5 0 5

Searles Valley Ground Water Basin (6-52)

Searles Valley Ground Water Basin, shown on Figure 46, is a predominantly northerly trending bow-shaped area of about 251 square miles, located in San Bernardino and Inyo Counties, within the Searles Lake Drainage Basin (No. 21).

The basin is bounded on the west by the Argus Range and Spangler Hills, on the east by the Slate Range, and on the south by the Summit Range and Lava Mountains. The basin floor ranges in elevation from 1,621 feet at Searles Lake to 3,300 feet in the southwest end of the basin. Elevations reach 6,500 feet in the Argus Range and about 5,500 feet in the Slate Range. Searles Lake occupies approximately 40 square miles in the central-north portion of the basin.

Geology

The Slate Range along the eastern edge of the basin consists predominantly of pre-Tertiary granitic and metamorphic rocks with some Paleozoic sediments on the northeast. On the south, the Garlock fault roughly parallels the trace of the Summit Range, which consists of pre-Tertiary granitic rocks and Tertiary volcanic rocks and sediments, and the Lava Mountains, which include Tertiary volcanic rocks and/or sediments. The Spangler Hills and the Argus Range to the west consist of pre-Tertiary granitic rocks.

Quaternary alluvium is exposed over a portion of the basin floor. The alluvium comprises a large portion of the upper valley fill; the valley fill extends to a depth of at least 750 feet. The playa deposits of Searles Lake, a crystalline type of playa, form another portion of the upper valley fill.

Water Supply

The principal source of ground water replenishment in the Searles Valley Ground Water Basin is percolation of streamflow originating in the watershed. The annual rainfall at Trona ranged from 1.8 to 11.5 inches for the period 1897-1947, averaging 4.4 inches annually. The mountains bordering the basin on the east and west may receive as much as ten inches of precipitation annually. There are no perennial streams flowing into the valley and any precipitation which occurs within the valley is normally lost by evaporation.

Limited recharge occurs principally in the upper slopes of the alluvial fans near the northern end of the basin. Subsurface inflow may occur from Salt Wells Valley basin, but because the basin has interior drainage, there is no surface or subsurface outflow. Usable ground water supplies are derived from the Recent and underlying older alluvial deposits.

Depths to water in 20 wells in the basin ranged from five to more than 300 feet. The hydraulic gradient which generally slopes toward Searles Lake has been modified locally by pumping depressions caused by constant withdrawals at Valley Wells where the gradient has been reversed so that it slopes toward Valley Wells at a rate of about three feet per mile, as shown on Diagram 10.

Development and Utilization. The development of Searles Valley was due to the discovery and mining of minerals in Searles Lake, the largest natural salt deposit in the Lahontan Region. Some metal mining has also occurred in the surrounding mountains, especially in the Slate Range. The chemical deposits of Searles Lake were discovered in 1863 and have been worked since 1873. Principal products are boron, cesium, lithium, potash, and soda ash.

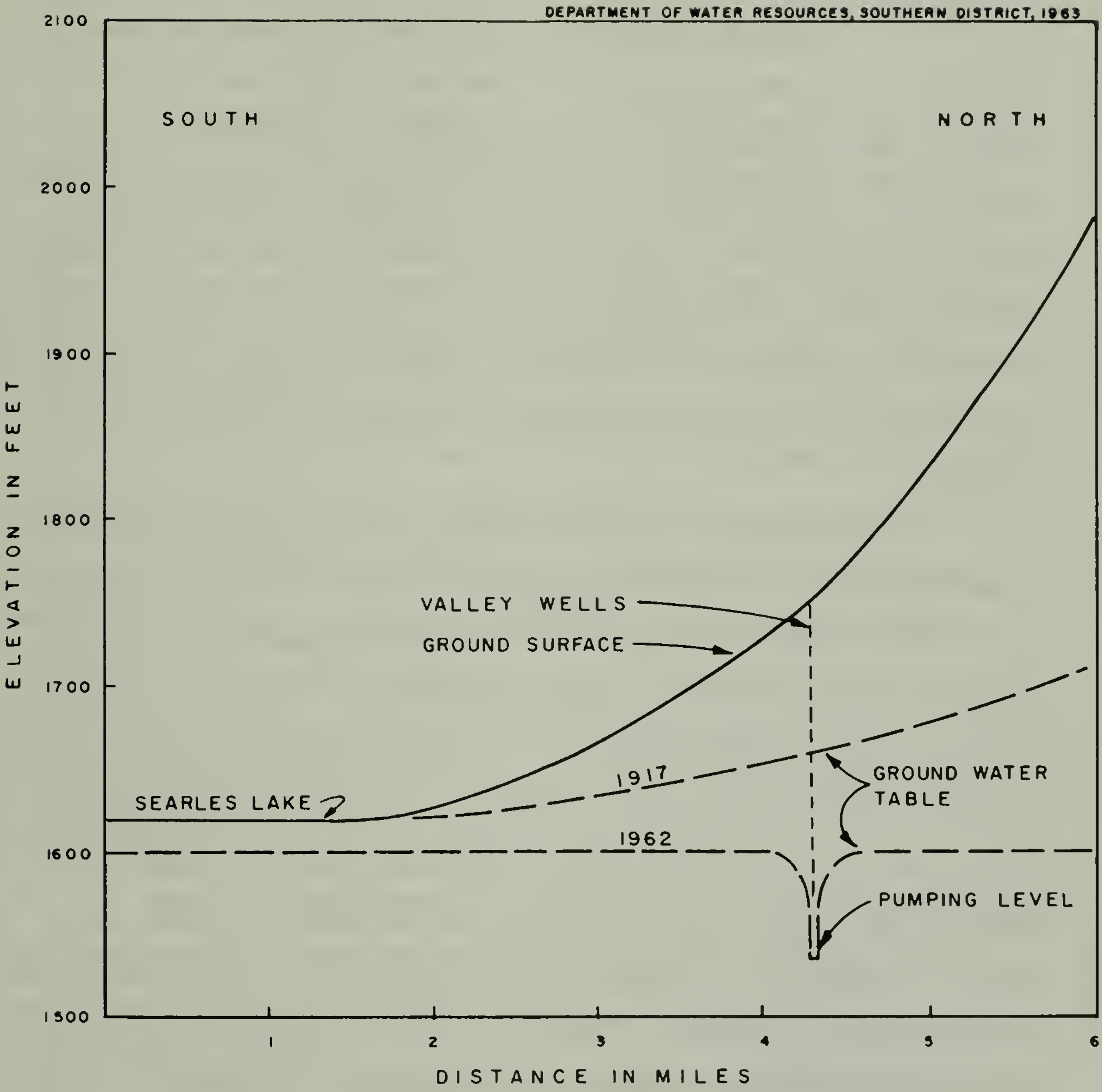


DIAGRAM 10. SECTION THROUGH GROUND WATER TABLE AT NORTH END OF SEARLES VALLEY

Three potash companies were established on the west side of the lakebed and the towns of Trona, Borosolvay, and Westend, which were mainly owned by these companies, grew around their processing plants. During World War I, when cheap potash was cut off from Germany, the production was pushed to unprecedented levels, and 3.5 million dollars worth of potash was sold in 1918. After the end of the war, the cheaper German potash went back on the market, and as a result, the operations at Searles Lake nearly ceased; the plant in Borosolvay was closed in the winter of 1921-22. Brine, from which the chemicals are processed, is pumped up from the "crystal body," in the center of the playa, and piped to the plants at its edge for processing.

Water levels in the wells originally drilled in the lakebed were either artesian or at the playa surface; one well was reportedly flowing at the rate of 40 gallons per minute in 1918. The American Trona Corporation dug several wells north of the lakebed in search of suitable quality water, but to no avail. Water for domestic use either was obtained from springs located on the east slope of the Argus Range or was hauled in by tank car. Domestic water for the plants at Borosolvay and Westend was hauled in by tank car from Cantil, located about 50 miles southwest in Fremont Valley. In the fall of 1917, 80,000 gallons of water per month were being used to supply 175 persons at Borosolvay. During the 1940's a 29-mile pipeline from Indian Wells Valley was constructed to import water for domestic use. Today, approximately 500 acre-feet is imported annually via this pipeline. In addition, about 100 acre-feet of water for domestic use is obtained from springs on the east slope of the Argus Range.

The present population in the Searles Valley basin area is estimated to be about 4,000; the town of Trona is the largest town. Almost

Approximately 9,500 acre-feet of brine is extracted from Searles Lake each year for chemical processing, and some 500 acre-feet of water is piped from Valley Wells for sluicing and sanitary purposes.

Water Quality. Ground water under Searles Lake is of inferior quality for domestic or irrigation use. The salt content of the ground water obtained at Valley Wells has increased greatly because a pumping depression draws the briny water from the lakebed toward Valley Wells. The total dissolved solids content of ground water at Valley Wells has increased from about 2,000 ppm to about 8,000 ppm between 1953 and 1960. Ground water in the far north end of the basin, as indicated by water from well 24S/43E-14L1, is of suitable quality for domestic use, but its high percent sodium makes it inferior for irrigation use. The ground water quality in the southern tip of the basin, near Searles Station, is of suitable quality for all beneficial uses. No wells are known to exist between Searles and Searles Lake; however, ground water of suitable quality could probably be found in this area. Data on water quality in the Searles Valley basin is shown on Figure 46 and Table 52.

Water from the springs in the Argus Range varies in quality and the total dissolved solids content ranges from 234 to 420 ppm. One of these springs has a high fluoride content and a second has a high nitrate content which impairs the water quality. However, when water from these springs is mixed with water from the other springs, the overall quality is suitable for domestic use. Water for domestic use imported from Indian Wells Valley has a total dissolved solids content of 390 ppm and is of suitable quality for all uses.

The character of the spring water in the Argus Range ranges from calcium-sodium bicarbonate to sodium-calcium bicarbonate; the wells in the north half of the valley exhibit a sodium chloride character. The water from well 28S/40E-22Q1 in the south end of the valley is calcium-magnesium chloride-bicarbonate in character.

The brine pumped from the crystal body in the lake bed has a total dissolved solids content of about 350,000 ppm which is about 10 times the concentration of total dissolved solids in the Pacific Ocean.

There appears to be no pollution problem due to domestic or industrial waste discharges in the valley. The main sewage plant at Trona discharges a chloride brine effluent through a primary treatment plant to the dry lakebed for evaporation and percolation.

TABLE 52

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
SEARLES VALLEY GROUND WATER BASIN (6-52)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	feet or cfs	Use
Homewood Canyon 23S/42E-34A1	DI						Ca-Na HCO_3	4-12-54	flow	Domestic
-34R1	I		D		F		Ca HCO_3	4-12-54	flow	Domestic Mining
-36A1	DI						Ca-Na HCO_3	4- 9-53	flow	Domestic
23S/43E-31D1	DI						Na-Ca HCO_3	4-12-54	flow	Domestic
-31L1	I	D		NO_3			Na-Ca HCO_3 -Cl	1956	flow	Domestic
Great Falls Basin 24S/42E-12A1	DI						Ca HCO_3	4-15-52	flow	Domestic
24S/43E-18P1	DI						Ca-Na HCO_3	4-10-56	flow	Domestic
Wilson Canyon 24S/42E-36A1	DI						Ca-Na HCO_3-Cl	1956	flow	Domestic
Stockwell Gold Mine Co. -14L1	D		I		% Na		Na Cl	3-15-54	306 ft	Unknown
Valley Wells -22M1			DI		EC, TDS, Cl B, F, SO_4, % Na		Na Cl	3-14-62	214.5ft ppg ft	Industrial

D - Domestic
I - Irrigation

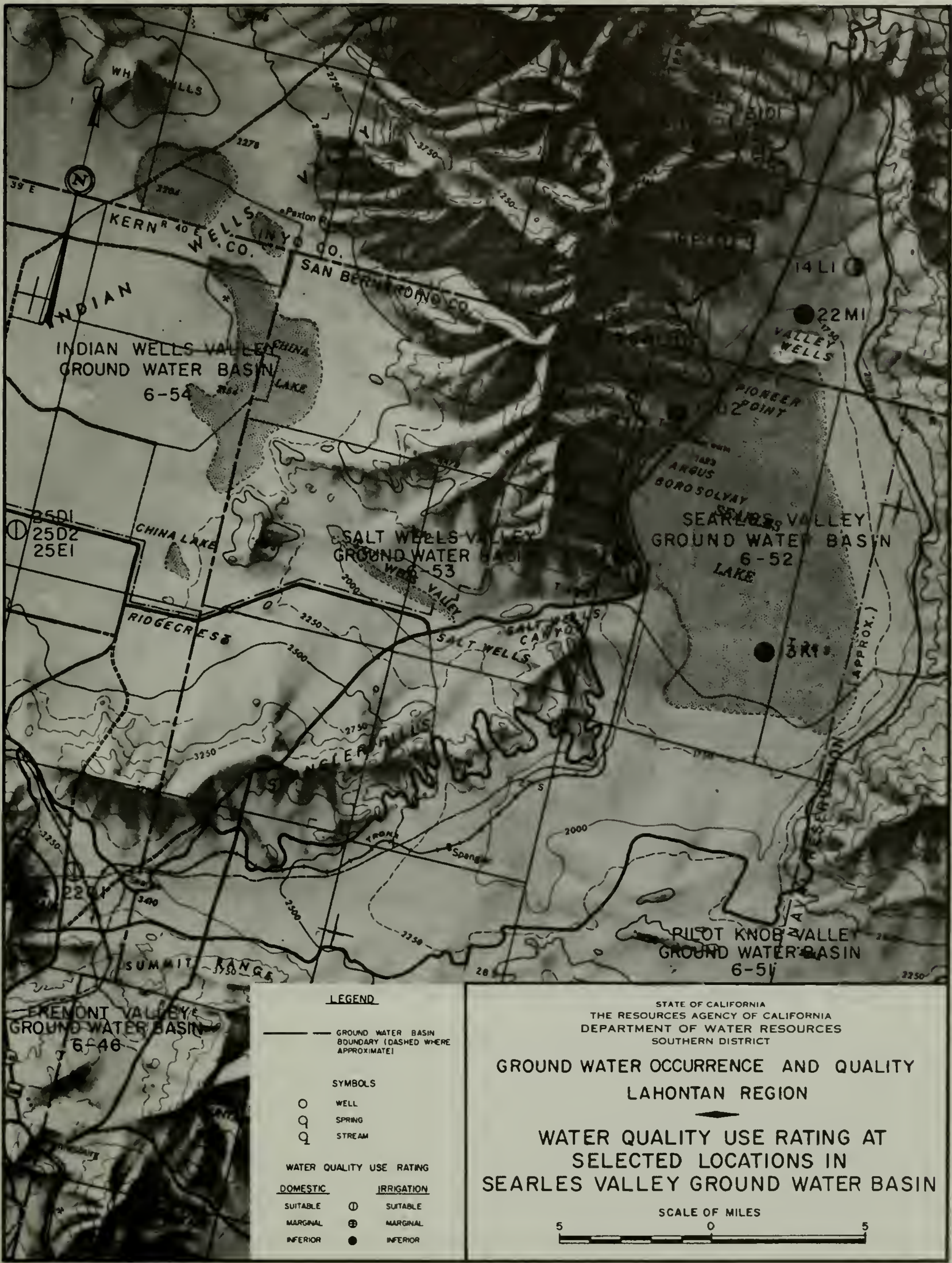
TABLE 52

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
SEARLES VALLEY GROUND WATER BASIN (6-52)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
25S/43E-17D2			DI		EC, TDS, Cl B, F, SO_4 % Na		Na Cl	3-14-62	126.3ft	Industrial
Westend 26S/43E-6C1			DI	NO_3	F, B, Cl, TDS, EC, SO_4 % Na		Na Cl	1-25-57	97.6ft	Industrial
Searles Lake Bed -13K1			DI		F, B, Cl, TDS, EC, SO_4 % Na, NO_3		Na Cl	1-25-57	5.8ft	Test
Searles Station 28S/40E-22Q1	DI						Ca-Mg Cl-HCO_3	4- 1-60	50.0ft	Domestic
Domestic Supply from Indian Wells Valley										
26S/39E-25D1	DI						Na Cl-HCO_3	10-20-53	181.08 ft.	Stock ?
-25D2	DI						Na Cl-HCO_3	4- 1-53	174.99 ft	Stock
-25E1	DI						Na Cl-HCO_3			Stock

D - Domestic
I - Irrigation

FIGURE 46



STATE OF CALIFORNIA
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DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN SEARLES VALLEY GROUND WATER BASIN

Salt Wells Valley Ground Water Basin (6-53)

Salt Wells Valley Ground Water Basin, shown on Figure 47, is an easterly trending, roughly shaped oval area of about 34 square miles located in San Bernardino County, within the Searles Lake Drainage Basin (No. 21).

The basin is bounded on the north by the Argus Range, on the east and west by low hills separated by alluvial divides, and on the south by the Spangler Hills. Elevation of the basin floor ranges from a low of about 1,800 feet, at the east end, to about 2,500 feet in the southern part of the basin. Maximum elevations rise to approximately 3,550 feet in the Spangler Hills and Argus Range. Salt Wells Valley Lake is a long, narrow one-square mile area located in the central part of the basin at an elevation of 2,130 feet, and is a dry type of playa.

Geology

Pre-Tertiary granitic rocks, which occur in the Argus Range to the north and the Spangler Hills to the south, define the limits of the Salt Wells basin. Pre-Tertiary granitic rocks also occur in the hills to the east and west. Passes through these hills, such as Salt Wells Canyon, connect Salt Wells basin to the adjoining basins.

Quaternary alluvium is exposed over a large portion of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 50 feet.

Water Supply

Sources of ground water replenishment to the basin are underflow from Indian Wells Valley, deep penetration of direct rainfall, and percolation of runoff. The basin receives an annual precipitation of four or five inches. There is no surface inflow to the basin; any runoff from the surrounding highlands drains to an easterly sloping wash which traverses the central axis of the valley toward Salt Wells Canyon.

Usable ground water supplies are derived from the Recent and underlying older alluvial deposits. Ground water moves easterly, as shown on Diagram 11, from Indian Wells basin to Salt Wells basin and on to Searles basin. Between each basin, there is a water level differential of about 250 feet.

The depth to ground water at Salt Wells is 20 feet. One and one-half miles east of Salt Wells, in Salt Wells Canyon, ground water rises to the surface during the wetter months and flows as a small stream of cool, clear, but salty water.

Development and Utilization. The basin has experienced very little development although it is part of a military reservation. A stage coach station existed at one time in the area where the roads from Randsburg and Ridgecrest join, and a dug well was located there. Well 26S/42E-29J1 was drilled between the intersection of the roads; when visited in 1960, it was abandoned. There is presently no extraction of ground water within the basin. A pipeline, which transports water from Indian Wells Valley to Searles Valley for domestic use, passes through Salt Wells Valley, but no use is made of this water in the basin.

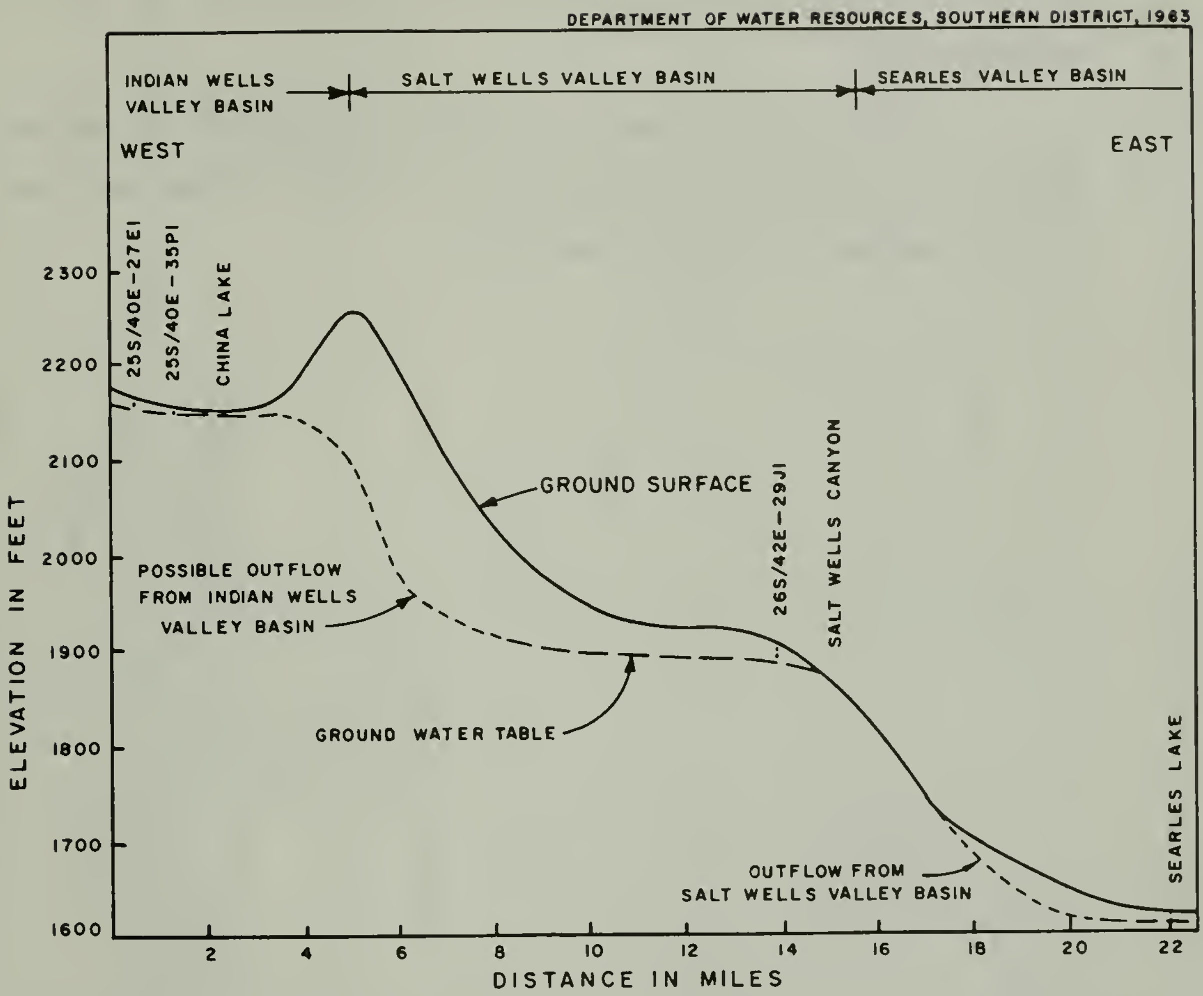


DIAGRAM II. SECTION THROUGH GROUND WATER TABLE IN INDIAN WELLS, SALT WELLS, AND SEARLES VALLEYS

Water Quality. The quality of water from well 26S/42E-29J1 is inferior for all beneficial uses, as shown on Table 53. This water has a sodium chloride character and contains more than 4,000 ppm total dissolved solids.

Ground water rising to the surface and flowing in Salt Wells Canyon has a total dissolved solid content of about 39,000 ppm, which is a little greater than that of sea water.

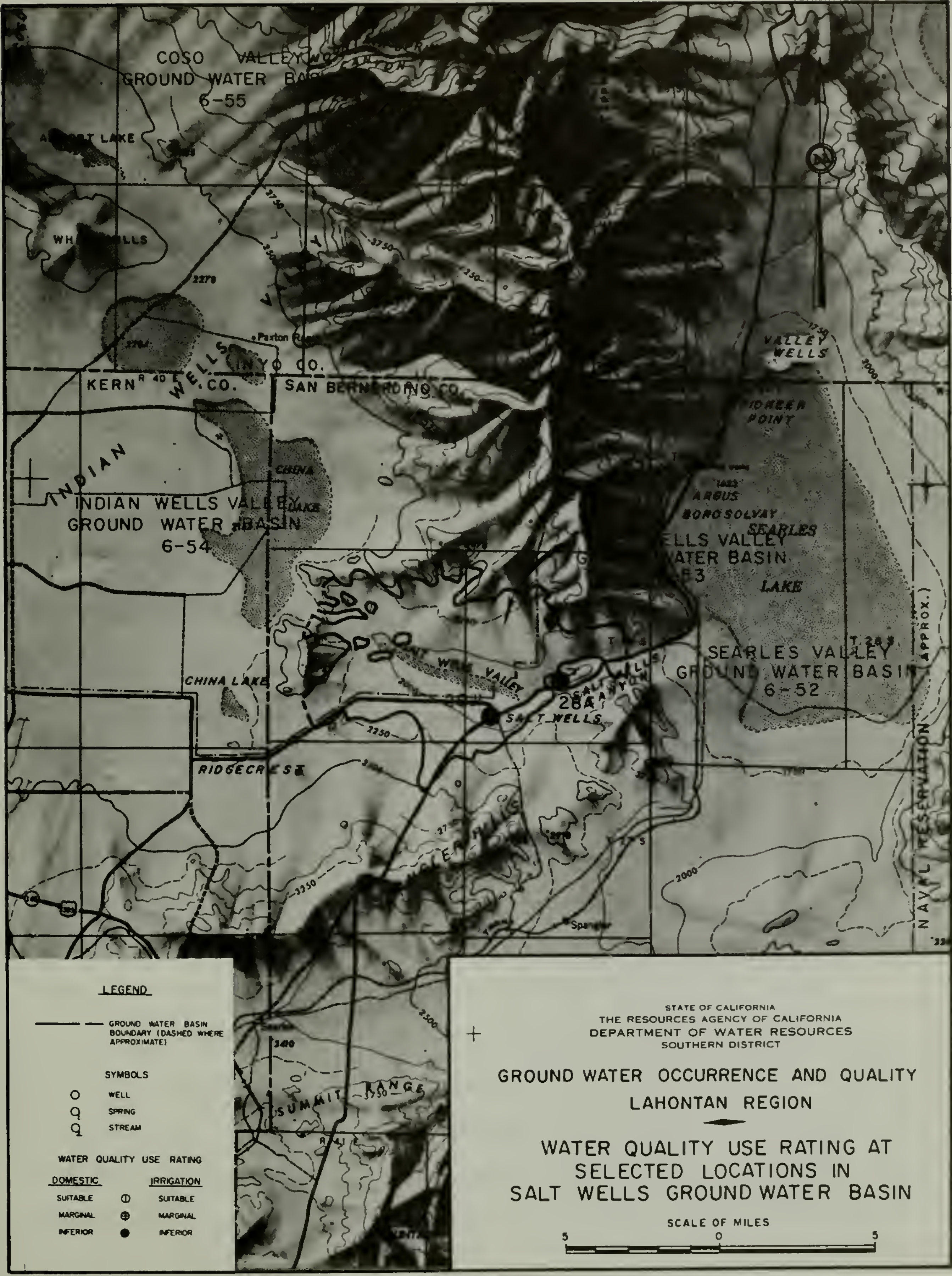
TABLE 53

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
SALT WELLS VALLEY GROUND WATER BASIN (6-53)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
26S/42E-29J1			D1		EC, TDS, Cl % Na, B		Na Cl	1-25-57	19.8 ft	Unknown
Salt Wells Canyon 26S/42E-28A			D1		EC, TDS, Cl % Na, B, SO_4		Na Cl	6- 5-53	flow	Unknown

D - Domestic
I - Irrigation

FIGURE 47


COSO VALLEY
GROUND WATER BASIN
6-55
INDIAN WELLS VALLEY
GROUND WATER BASIN
6-54
SEARLES VALLEY
GROUND WATER BASIN
6-52
VALLEY WELLS
PIONEER POINT
ARGUS
BOROSOLVAY
SEARLES
LAKE
CHINA LAKE
RIDGECREST
SALT WELLS
28A
INYO CO.
KERN CO.
SAN BERNARDINO CO.
NAVAL RESERVATION (APPROX.)
SUMMIT RANGE
Paxton Ranch
Spangler
2000
2250
2500
3250
3750
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
SUITABLE
MARGINAL
MARGINAL
INFERIOR
INFERIOR
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SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN
SALT WELLS GROUND WATER BASIN
SCALE OF MILES
5
0
5

Indian Wells Valley Ground Water Basin (6-54)

Indian Wells Valley Ground Water Basin, shown on Figure 48, is a northeasterly trending irregularly shaped area of about 519 square miles located in San Bernardino, Kern, and Inyo Counties, within the Searles Lake Drainage Basin (No. 21).

The basin is bounded on the north by the White Hills and an alluvial divide, on the east by the Argus Range, on the south by the El Paso Mountains, and on the west by the Sierra Nevada. China Lake, at an elevation of 2,153 feet, is the low point in the basin and covers an area of seven square miles. From this dry lake, the basin floor rises to elevations of 3,200 feet. Elevations in the bordering mountains reach a maximum of 8,475 feet in the Sierra Nevada and 6,562 feet at Argus Peak.

Geology

Quaternary volcanic rocks and playa deposits, and an alluvial divide occur along the northern edge of the basin. The Argus Range on the east and the Spangler Hills on the southeast consist of pre-Tertiary granitic rocks. To the south, the El Paso Mountains and the El Paso Peaks area consist of pre-Tertiary metamorphic and granitic rocks, Paleozoic sediments, Tertiary sediments, and Quaternary volcanic rocks. The Sierra Nevada to the west of the basin consists of pre-Tertiary granitic rocks.

Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 1,350 feet. A pressure area exists in the vicinity of China Lake, a moist, clay encrusted type of playa. Numerous northwest trending faults occur throughout the basin and in the adjoining hill and mountain areas. The northerly trending Sierra Nevada fault zone extends along the western edge of the basin at the base of the Sierra Nevada.

Water Supply

The principal source of ground water replenishment in Indian Wells Valley Ground Water Basin is percolation of streamflow originating in the watershed. The annual precipitation at Armitage Field in the Naval Ordnance Test Station for the period 1946-1958 ranged from 0.14 to 5.88 inches, averaging 2.19 inches annually. The annual precipitation falling on the Sierra Nevada is more than 15 inches. Runoff from this range drains into ten major canyons to the upper slopes of the alluvial fans where it percolates into the coarse sediments, becoming the principal source of ground water in the basin. Usable ground water supplies are derived from the Recent and underlying older alluvial deposits. Recharge to the ground water basin from all sources has been estimated to be about 40,000 acre-feet annually.

Movement of ground water includes percolation at the foot of the Sierras and lateral displacement toward China Lake; evapotranspiration from this lake is estimated to occur at about 8,000 acre-feet per year. The only known subsurface outflow from the basin consists of an estimated 20 acre-feet moving to Salt Wells Valley Ground Water Basin through the narrows southeast of China Lake as shown on Diagram 11.

Water levels near the town of China Lake have fallen about 20 feet since 1945 because of greatly accelerated extractions. However, the water table near the area of the dry lake and near the outer edges of the basin has remained relatively constant. Depth to water is generally between 200 and 300 feet below the surface near the Sierra Nevada, but the water table occurs at or above the ground surface near China Lake. A pumping depression exists in the vicinity of Ridgecrest; water levels are from 105 to 150 feet below the surface.

The hydraulic gradient slopes toward the dry lake from the Sierra Nevada at a rate of four to six feet per mile; from the southwest finger of the basin, the slope toward the dry lake is about 20 to 40 feet per mile.

Development and Utilization. A survey of Indian Wells Valley basin in 1920 revealed the existence of 108 wells, generally distributed in an "L"-shaped band to the west and south of China Lake. At that time, pumping was most extensive near the central portion of the basin. Most of the water was utilized in irrigated agriculture, and there were 800 acres of crops; apples, pears, peaches, and alfalfa. Total extraction of ground water was about 2,900 acre-feet per year.

By 1942, there were 177 wells situated in the same general area. However, the center of heavy pumping had shifted to the southeastern corner of the valley near the City of Ridgecrest. Ground water extraction for irrigated agriculture had been reduced, the total acreage having been decreased to approximately 250 acres of alfalfa. Although demands for ground water had increased with exports of water for industrial developments (beginning in the 1940's) at Trona, in Searles Valley, the large decrease in irrigated agriculture resulted in an overall reduction in ground water use to about 2,300 acre-feet per year.

In 1953, there were 240 wells. Most of these wells were generally within the central portion of the basin, but the newer and major wells, supplying Ridgecrest and the Naval Ordnance Test Station at China

Lake, had been dispersed over a larger area. New wells were drilled north and west of Ridgecrest, and the area of greatest pumping moved nearer the town of China Lake. Agricultural developments had decreased to about 60 acres of alfalfa, and the population had increased to about 2,300. Industrial requirements for ground water at Trona had risen to 500 acre-feet annually, and the military base used more than 700 acre-feet, resulting in a combined pumping of approximately 2,800 acre-feet that year.

By 1959, the number of wells had increased to 260. Irrigated agriculture had increased to 300 acres of alfalfa, and the basin population had jumped to 24,000. Military activity at the Naval Ordnance Test Station had greatly increased, and more than half of the extracted ground water of the basin was utilized by the Test Station. About 500 acre-feet of water was exported to Trona. An estimated 9,300 acre-feet of ground water was extracted from the basin in 1959.

Water Quality. The quality of the ground waters in the basin appears to have remained relatively constant since 1920. Water of suitable quality is found in the central-west area but toward the east, the quality becomes generally marginal to inferior in the vicinity of China Lake as shown on Figure 48 and Table 54. Some waters rated as inferior for domestic and irrigation uses are also found in the southwest end of the valley. The total dissolved solids content in the ground waters in the central-west and southwest areas generally is in the 200 to 500 ppm range, but in the area of the dry lakes, it is 5,000 ppm or more. Ground water in the central-north side of the valley has a total dissolved solids content ranging from 500 to 800 ppm, and in the central-south side, ranging from 250 to 300 ppm.

The ground water in the vicinity of China Lake generally is rated as inferior in quality for most uses. The marginal and inferior quality of water in other areas is mainly due to either high concentrations of boron and fluoride, or percent sodium. For example, the waters from two wells in the southwest tip of the valley (27S/38E-31D1 and 28S/38E-18R1) has a total dissolved solids content of less than 500 ppm but a fluoride concentration of eight ppm and percent sodium of 90. Water from the vicinity of the dry lake may eventually move southerly into the pumping depression near Ridgecrest.

Runoff from the Sierra Nevada is predominantly calcium bicarbonate in character. It becomes sodium bicarbonate in character as it moves through alluvium and sodium chloride near the dry lake areas.

The sewage treatment plant for Ridgecrest is two miles southeast of town. All effluent from this plant is utilized for crop irrigation. The sewage treatment plant for China Lake is located about one mile north of town. Effluent from this plant is discharged to lagoons from which approximately 75 percent is pumped for irrigation of a golf course.

TABLE 54

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
INDIAN WELLS VALLEY GROUND WATER BASIN (6-54)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Surface flow from Little Lake 23S/38E-18H		D	I	F	B		Na HCO_3	3-20-46	flow	Unknown
24S/40E-33N1*			DI		EC, TDS, B Cl, % Na		Na Cl	5-11-53	3.2 ft.	Unknown
Sand Canyon Surface flow 25S/38E-8J	I	D		F			Ca HCO_3	3-19-46	flow	--
-11K2	DI						Na HCO_3	6-5-53	189.5ft	Unknown
-23G1	DI						Na HCO_3	3-17-54	202.4ft	Unknown
-30D1	DI						Ca HCO_3	4-17-52	flow	--
25S/39E-2E1		DI		F, B			Na HCO_3	3-17-54	37.2ft	Unknown
-7K1	I		D	% Na	B		Na HCO_3	3-17-54	99.1 ft	Unknown
-24D1	DI						Na HCO_3	3-17-54	19.6 ft	Unknown
-28P1	DI						Ca-Na SO_4-HCO_3	3-17-54	30.9 ft	Unknown

D - Domestic
I - Irrigation
* - F not determined

TABLE 54

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN INDIAN WELLS VALLEY GROUND WATER BASIN (6-54)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
25S/40E-12M1**			DI	SO_4	EC, Cl, TDS, % Na		Na Cl	3-17-54	1.3 ft	Observation
-24N1*			DI		EC, Cl, SO_4 TDS, B		Mg-Ca Cl	3-17-54	6.5 ft	Observation
-35P1			DI		EC, SO_4, Cl B, TDS, % Na		Na Cl	3-17-54	9.0 ft	Observation
25S/41E-28B1***			DI		EC, Cl, B			5-13-54	67.6ft	Test
26S/38E-17E1	I	D		F			Ca-Na SO_4-HCO_3	3-14-53	75.9 ft	Stock
26S/39E-14E1	DI						Ca-Na HCO_3	3-17-54	131.4ft	Unknown
-19Q1	DI						Na-Ca Cl	11-20-59	216.2ft	Military
-24P1		D	I	F	% Na		Na HCO_3	11-20-59	160.0ft	Military
-24Q1	DI						Ca-Na HCO_3	3-17-54	158.6ft	Military
-24R1	I	D		F			Na HCO_3	10-14-55	154.3ft	Military

D - Domestic
I - Irrigation

* - F not determined
** - F and B not determined
*** - Only EC, Cl and B determined

TABLE 54

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
INDIAN WELLS VALLEY GROUND WATER BASIN (6-54)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
26S/39E-30J1	DI					15.4 + 1.9	Na HCO_3	4-2-53	235.1ft.	Military
26S/40E-5F1		DI		%Na, F			Na HCO_3-Cl	3-17-54	21.8 ft	Unknown
-5P1		D	I	% Na, F	B		Na Cl-HCO_3	3-17-54	30.2 ft	Military
-7E1	D		I	EC, % Na	B		Na HCO_3	2-12-52	81.4 ft	Domestic
-11A1*			DI		EC, TDS, SO_4 Cl, B, % Na		Na Cl	3-17-54	2.1 ft.	Observation
-15E1		D	I	F	% Na, B		Na HCO_3	3-17-54	48.2 ft	Unknown
-18N1		DI		% Na, F			Na HCO_3	4-5-55	124.3ft	Unknown
-22N1			DI		% Na, B, F		Na HCO_3	4-4-55	78.2 ft	Unknown
-22P1			DI	TDS, EC	% Na, B, F		Na HCO_3	3-17-54	64.4 ft	Unknown
-33P1	DI						Na-Ca HCO_3-Cl	3-17-54	130.5ft	Military

D - Domestic
I - Irrigation
* - F not determined

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN INDIAN WELLS VALLEY GROUND WATER BASIN (6-54)

(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	feet or cfs	Use
26S/40E-34N1	D	I		% Na			Na HCO_3	11-20-59	112.0ft	Military
41E-7G1*			DI		EC, TDS, B, Cl, SO_4, % Na		Na Cl	3-17-54	24.8 ft	Unknown
27S/38E-28R1	I	D		F			Na-Ca HCO_3	4-5-53	170.5ft	Stock
-31D1			DI		% Na, F		Na HCO_3			Domestic
39E-7R1	I	D		F			Na-Ca HCO_3	3-17-54	347.5ft	Stock
40E-3P1			DI		EC, TDS, Cl, B		Na Cl			Unknown
-4L1	D		I		% Na		Na HCO_3-Cl	4-7-55	137.6ft	Military
-10A1	D	I		% Na, B			Na Cl	4-6-55	106.9ft	Domestic
-10C1			DI	% Na	B, Cl, EC, TDS		Na Cl	3-17-54	108.9ft	Irrigation
-15L1		DI		EC, B, Cl, TDS			Na Cl			Domestic

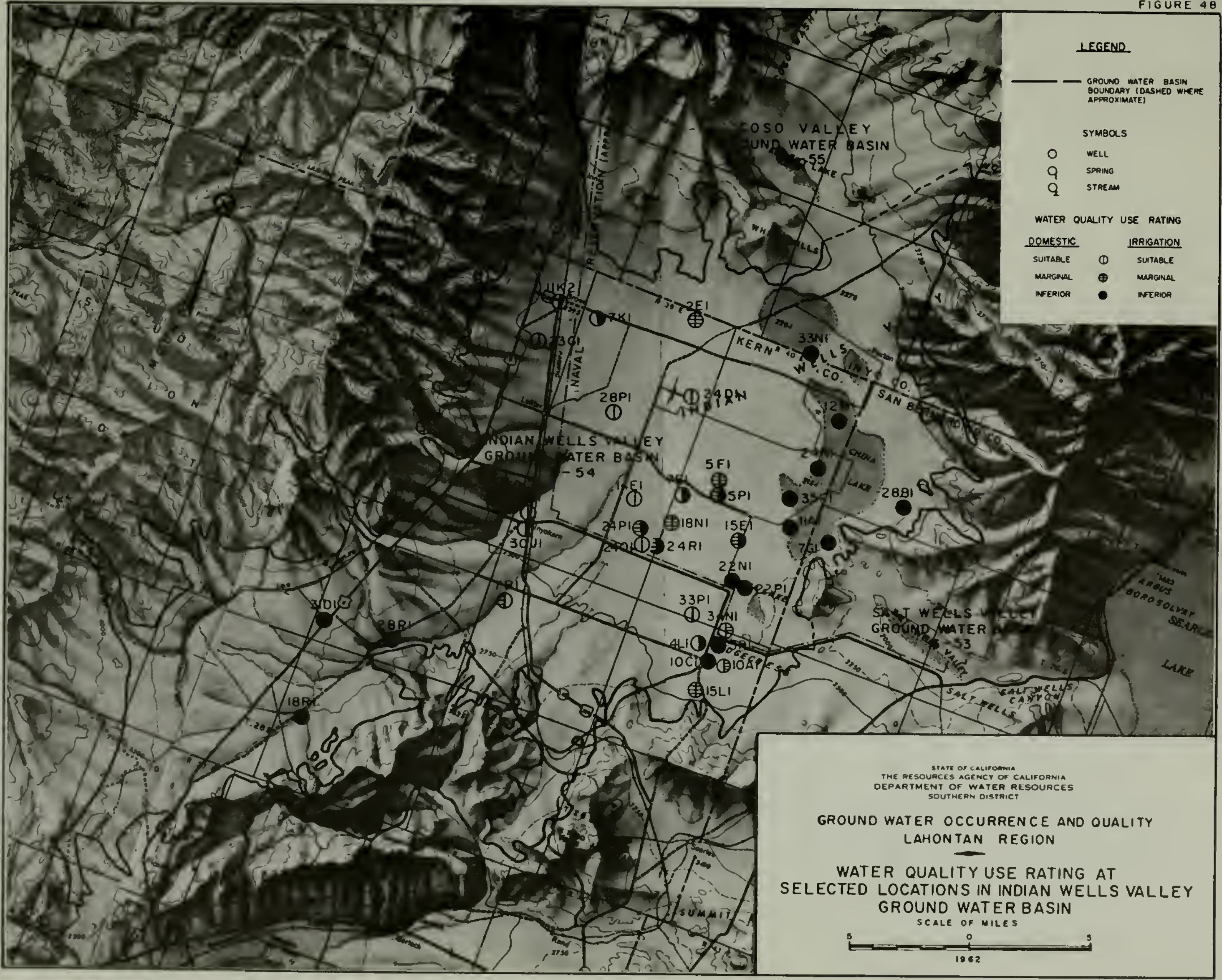
D - Domestic
I - Irrigation
* - F not determined

TABLE 54

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
INDIAN WELLS VALLEY GROUND WATER BASIN (6-54)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
28S/38E-18R1			DI		F, % Na		Na HCO_3	3-29-60	213 ft	Stock

D - Domestic
I - Irrigation



STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN INDIAN WELLS VALLEY
GROUND WATER BASIN

SCALE OF MILES
5 0 5

1962

Coso Valley Ground Water Basin (6-55)

Coso Valley Ground Water Basin, shown on Figure 49, is a northerly trending arcuately shaped area of about 52 square miles, located in the southwest corner of Inyo County, within the Searles Lake Drainage Basin (No. 21).

This basin is bordered on the north by the Coso Range, on the east by the Argus Range, on the south by the White Hills, and on the west by volcanic highlands.

The floor of the basin ranges in elevation from 2,260 feet at Airport Lake, which covers an area of about 2.0 square miles, to about 3,200 feet at the northern limits of the basin. A few of the surrounding peaks reach elevations of 6,000 feet.

Geology

The Coso Range to the north consists of Quaternary volcanic rocks; the Argus Range to the east consists of pre-Tertiary granitic rocks, with some Quaternary volcanic rocks. The White Hills area to the south consists of Quaternary volcanic rocks and playa deposits and an alluvial high. Pre-Tertiary granitic and Quaternary volcanic rocks occur in the highlands to the west.

Quaternary alluvium is exposed over much of the valley floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 117 feet. Airport Lake is a dry type of playa.

Water Supply

The principal source of ground water replenishment in Coso Valley Ground Water Basin is percolation of streamflow originating in the watershed.

The basin receives an annual rainfall of about five inches. Surface runoff from the Coso and Argus Ranges flows from the outer edges of the basin towards Airport Lake. The northern end of the valley is drained by the Coso Wash.

The fans of the Coso and Argus Ranges are the principal recharge areas and are capable of a moderate recharge rate. Ground water in the Recent and underlying older alluvium generally moves southerly and probably flows into Indian Wells basin. Water was found at a depth of about 117 feet below the surface in well 24S/40E-6A1, drilled about one mile southeast of the dry lake; in a well about four miles south in Indian Wells basin, the water level was about 60 feet lower. If there is continuity between these wells the hydraulic gradient would be 15 feet per mile.

Development and Utilization. The basin has undergone very little development other than the mining and the military operations. In the early 1900's, Darwin Road, which traverses the southeast edge of the valley, was one of the main routes to the Darwin and Coso mining districts and to Ballarat in Panamint Valley. During the 1930's, quicksilver was mined from the area around Coso Hot Springs. Approximately $17,000 worth of quicksilver was produced from 1935 to 1939, but production ceased in 1940.

One well known to have existed in the valley has been destroyed; the prior use of its waters is unknown. At present there is no extraction of ground water in the basin.

Water Quality. There are no available analyses of water from well 24S/40E-6A1, however, water from well 24S/40E-20J1 about two miles south of the Coso basin, in Indian Wells basin, is of marginal quality due to a chloride concentration of 508 ppm. This may indicate that ground water in Coso basin is also of marginal quality, since ground water probably flows from Coso basin to Indian Wells basin.

Water from the Coso Hot Springs, in the northwest tip of the basin, has been reported to have a high dissolved salts content. A sample collected in 1910 had a sulfate concentration of 1,400 ppm. Any water contributed to the basin from this source would be poor quality water. An analysis of a surface sample (23S/41E-8J) from Mountain Springs Canyon indicates that suitable quality water flows from this canyon to the basin. As shown on Table 55, water from this source has been rated as suitable for domestic and irrigation uses.

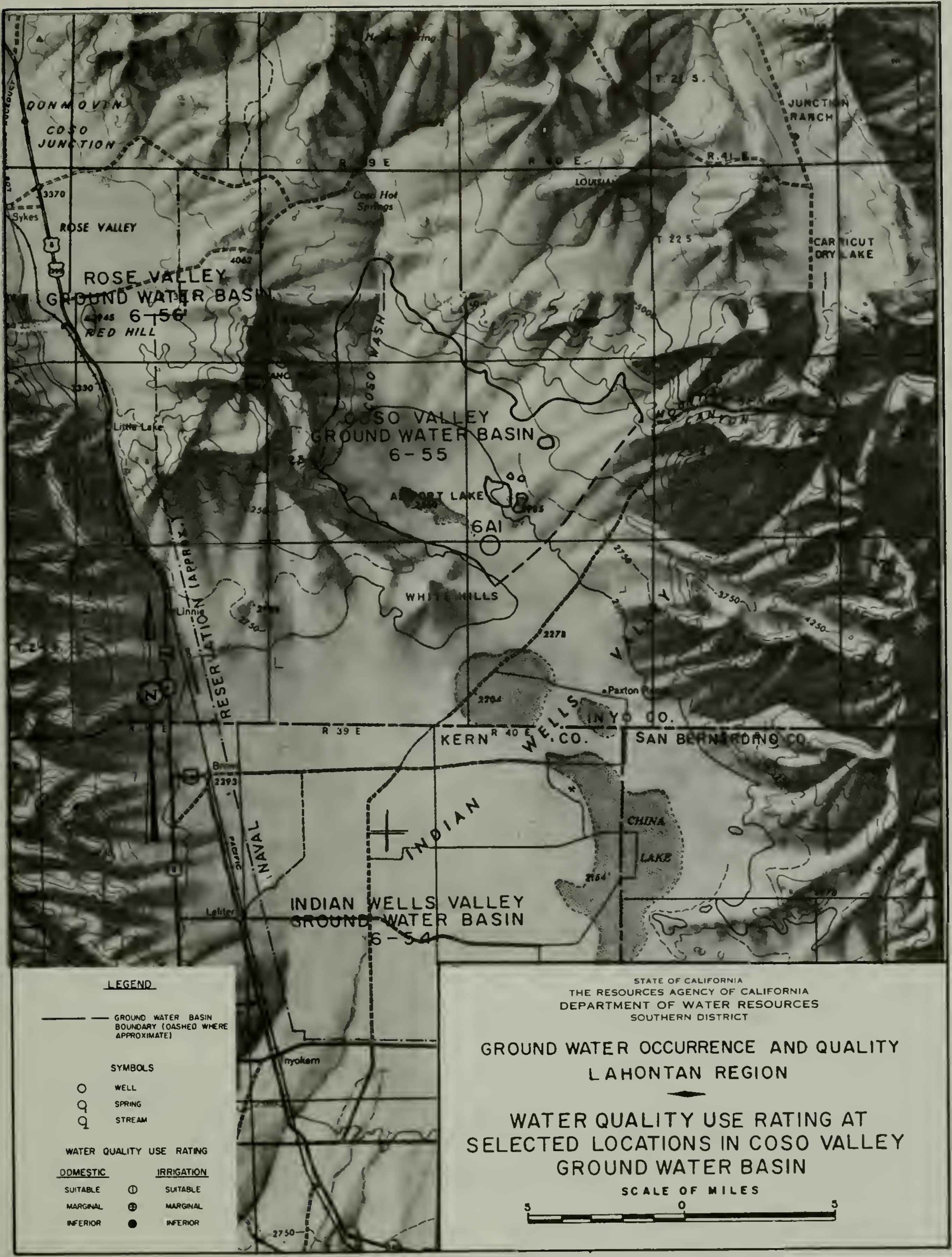
TABLE 55

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
COSO VALLEY GROUND WATER BASIN (6-55)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Mountain Springs Canyon 23S/41E-8J	DI						Ca-Na HCO_3	3-21-46	flow	Unknown

D - Domestic
I - Irrigation

FIGURE 49


ROSE VALLEY
GROUND WATER BASIN
6-56
COSO VALLEY
GROUND WATER BASIN
6-55
6A1
INDIAN WELLS VALLEY
GROUND WATER BASIN
6-54
WHITE HILLS
INYO CO.
KERN CO.
SAN BERNARDINO CO.
CHINA LAKE
COSO JUNCTION
JUNCTION RANCH
R 39 E
R 40 E
T 22 S
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
SUITABLE
MARGINAL
MARGINAL
INFERIOR
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN COSO VALLEY
GROUND WATER BASIN
SCALE OF MILES
5
0
5

Rose Valley Ground Water Basin (6-56)

Rose Valley Ground Water Basin, shown on Figure 50, is a rectangular-shaped, northerly trending area of about 61 square miles located in the southwest corner of Inyo County, within the Searles Lake Drainage Basin, (No. 21).

This basin is bounded on the north by an alluvial high, on the east by Coso Range, on the south by Volcano Peak, and on the west by the Sierra Nevada.

Mountain peaks in the Sierras rise to elevations of over 9,000 feet, those in the Coso Range attain an elevation of over 6,000 feet. The valley floor ranges in elevation from 3,140 feet at Little Lake, to 4,200 feet along the west side of the basin.

Geology

An alluvial high on the north occurs between the pre-Tertiary granitic rocks of the Sierra Nevada to the west and the Tertiary granitic and Tertiary volcanic rocks of the Coso Range to the east. Pre-Tertiary granitic and Quaternary volcanic rocks occur to the south in the Red Hill-Volcano Peak area.

Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 176 feet. The dry lake in Rose Valley basin is a dry type of playa; it is one of the smallest in the Lahontan Region.

Water Supply

The principal source of ground water replenishment in Rose Valley basin is percolation of streamflow originating in the watershed.

The valley floor annually receives about five inches of precipitation. Precipitation at the higher elevation, in the Sierra Nevada, may be as much as 25 inches annually, making this the area of greatest runoff in the basin. All runoff flows to the center of the valley and then southerly. A slight ridge in the valley floor just north of Red Hill blocks the surface flow causing water to pond; eventually it evaporates, leaving several small playas.

Lower Haiwee Reservoir, which extends over the divide between Owens and Rose Valleys, regulates the flow of water from the Owens River to the City of Los Angeles. Although water from the Owens River is not available for use in the Rose Valley basin because it is exported by conduit, some inflow to the basin may result from seepage from the reservoir.

The fans of the Sierra Nevada are considered to be the principal recharge areas and are capable of a moderate to high recharge rate. Ground water in the Recent and underlying older alluvium, moves south toward Little Lake. This lake, maintained by spring flow, is bounded on its southern edge by volcanic rocks which probably prevent or impede underflow to Indian Wells Valley.

The depth to water ranges from flowing conditions at Little Lake to 142 feet below the surface at Coso Junction. The water table gradient between these two points is about ten feet per mile.

Development and Utilization.

The valley has experienced very little development and ground water is utilized mainly for domestic purposes. About 125 people have permanent residence in the basin area, most of whom reside at Little Lake and Coso Junction. Most of the land in the valley is owned by the federal government and is not used. Little Lake, a small privately owned body of water in the southern end of the valley, is used for recreational purposes. An irrigable area exists in the northwest part of the basin but the depth to ground water is considerably greater (142 feet at Coso Junction) than in the southern part of the basin.

About six wells in the valley are pumped and the water is mainly used for domestic purposes; these wells are at Little Lake and Coso Junction. In addition, spring water is utilized at several locations. Spring water is piped from Talus and Sacatar Canyons of the Sierra Nevada to the valley floor. Residents at Little Lake and at the Lewis Ranch (two miles west of Coso Junction) also utilize spring water. It is estimated that a total of 50 acre-feet of water is utilized annually in the valley.

Water Quality. As shown on Figure 50 and Table 56, the quality of ground water in the northwest portion of the valley is suitable for irrigation or domestic use. Total dissolved solids content in these waters is about 350 ppm. Analyses of water from wells and springs near Little Lake, however, show that the water is high in boron, averaging 4.0 ppm, and therefore it would be rated as inferior for irrigation. The total dissolved solids content of this water is also high, ranging from 700 to 1300 ppm, therefore, some waters are rated as marginal for domestic use.

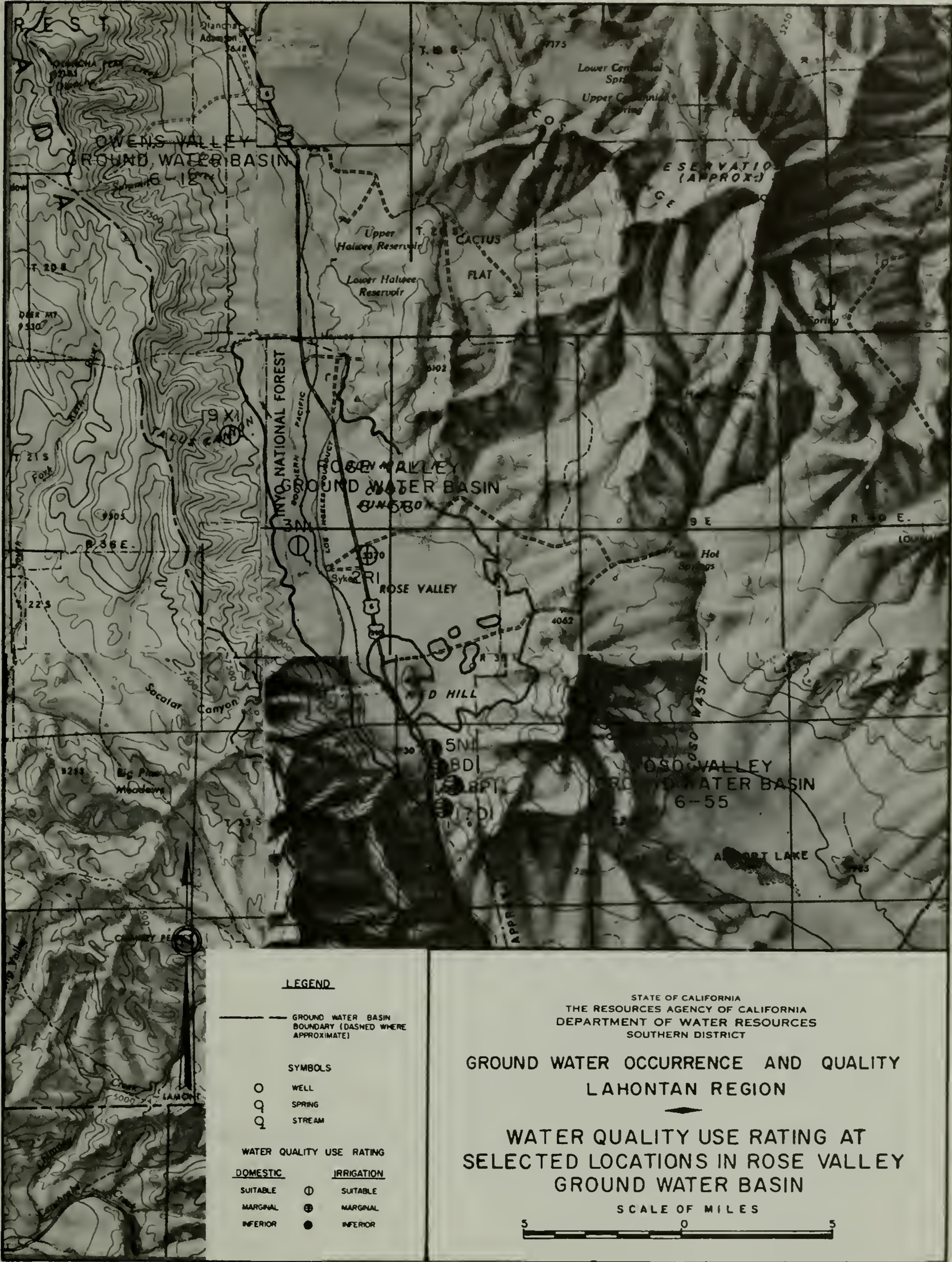
The character of the ground water in the northwest portion of the basin is calcium-magnesium bicarbonate, but in the south end of the basin the sodium ion replaces calcium or magnesium.

TABLE 56

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
ROSE VALLEY GROUND WATER BASIN (6-56)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
Dunmovin 21S/37E-19X1	DI						Ca-Mg HCO_3	7-13-55	flow	Domestic
Coso Junction 22S/37E-2R2	DI						Ca-Mg HCO_3	3-30-60	142.0	Domestic Irrigation
-3N1	DI						Ca-Mg HCO_3	7-15-55	flow	Domestic
Little Lake 23S/38E-5N1	D		I	% Na	B		Na HCO_3	3-30-60	19.0	Domestic
-8D1		D	I	F	B		Na-Ca HCO_3	7-15-55	flow	Unknown
-8P1		D	I	TDS, EC	B		Na-Ca HCO_3	7-13-55	flow	Domestic
-17D1		D	I	TDS, EC	B		Na-Mg HCO_3	9- 4-59	1.52	Domestic

D - Domestic
I - Irrigation



STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN ROSE VALLEY GROUND WATER BASIN

SCALE OF MILES
5 0 5

Darwin Valley Ground Water Basin (6-57)

Darwin Valley Ground Water Basin, shown on Figure 51, is a long, narrow northerly trending area of about 70 square miles located in the southeast portion of Inyo County, within the Searles Lake Drainage Basin (No.21).

Darwin Basin is bordered on the north by Ophir Mountain, by the Argus Range on the east and southeast, and by the Coso Range on the southwest and west.

The Argus Range attains a maximum elevation of 8,839 feet and the Coso Range reaches an elevation of 8,160 feet. The floor of the basin ranges in elevation from 3,500 feet at the northwest corner to 5,800 feet along the southern limits of the basin.

Geology

Pre-Tertiary granitic rocks, Paleozoic sediments, and Quaternary volcanic rocks occur to the north in the Ophir Mountain area. In the Argus Range to the east and southeast, pre-Tertiary granitic rocks and Paleozoic sediments occur with some Quaternary volcanic rocks. The Coso Range to the west and southwest consists of pre-Tertiary granitic and Quaternary volcanic rocks.

Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 250 feet. Outcrops of Tertiary and/or Quaternary sediments occur in the foothills along the eastern and western margins of the basin. A prominent structural feature in the Ophir Mountain area is the westerly trending Darwin fault.

Water Supply

The principal source of ground water replenishment in the Darwin Valley Ground Water Basin is percolation of streamflow originating in the watershed.

The basin receives an annual rainfall of about five inches. Runoff is derived mainly from the Argus and Coso Ranges where precipitation at the higher elevations may be as much as 10 inches annually. The northern two-thirds of the basin is drained by Darwin Wash in which runoff flows northward to the end of the basin and then northeastward to Panamint Valley. Runoff may also reach the Darwin Wash by way of Lucky Jim Wash, which drains the northwest arm of the valley. The southern one-third of the basin drains to Carricut Lake and southeasterly to Water Canyon which is tributary to Panamint Valley.

The fans of the Argus and Coso Ranges are the principal recharge areas and are capable of a moderate to high recharge rate. Ground water in the Recent and underlying older alluvium moves predominantly northward, flowing from this basin to Panamint Valley basin via Darwin Wash. Depth to water in the northeast end of the basin at well 19S/41E-16G1 is about 19 feet. During periods of pumping, the depth to water increases to about 38 feet. In test well 21S/41E-25N1, at the Junction Ranch, water was found at a depth of 242.5 feet.

Development and Utilization. The development of the valley began in 1874 when lead, silver, and zinc deposits were discovered. The town of Darwin boomed to a population of 5,000 by 1880, but by 1888 mining had nearly ceased; mining operations have been intermittent since that time.

The town of Darwin was reported to have obtained its water by pipeline from Coso Springs, which is about eight miles southwest of Darwin in the Coso Range. These springs are about one and one-half miles east of Coso which was a prominent mining and agricultural settlement in the early 1900's, as well as a stopping point for travelers. Junction Ranch, which is in the southern end of the basin, was also a main stopping point. Both of these settlements received their water supplies from springs.

Civilian activity is centered in the northern end of the basin, because the southern two-thirds is part of a Naval Reservation. Water for the Darwin area is obtained from wells at the head of Darwin Canyon in Darwin Wash. This wash is used for the domestic supply at Darwin as well as for the mining operations. In 1960, the area was almost inactive and very little ground water was being utilized. At that time, about 75 people had residence in the valley. It is estimated that 15 acre-feet of ground water is extracted annually, but during prior periods of mining, extraction was probably about 200 acre-feet per year.

Water Quality. Analyses of ground water from well 19S/41E-16G1 indicate that the water is of suitable quality for domestic and irrigation uses, as shown on Table 57. However, water from well 19S/41E-17A1, which is about three-quarters of a mile west of this well is rated as marginal because of the boron content (1.65 ppm) and the sulfate content (268 ppm). This difference in quality may be due to the fact that well 19S/41E-17A1 evidently is perforated in the older alluvium, whereas the Darwin wells are in a narrow strip of Recent alluvium along Darwin Wash. Water obtained from the wells in Darwin Wash area has a total dissolved solids content of about 350 ppm, and is calcium-sodium bicarbonate-sulfate in character. Water from well 19S/41E-17A1 has a total dissolved solids content of about 750 ppm and is sodium-calcium sulfate-bicarbonate in character.

TABLE 57

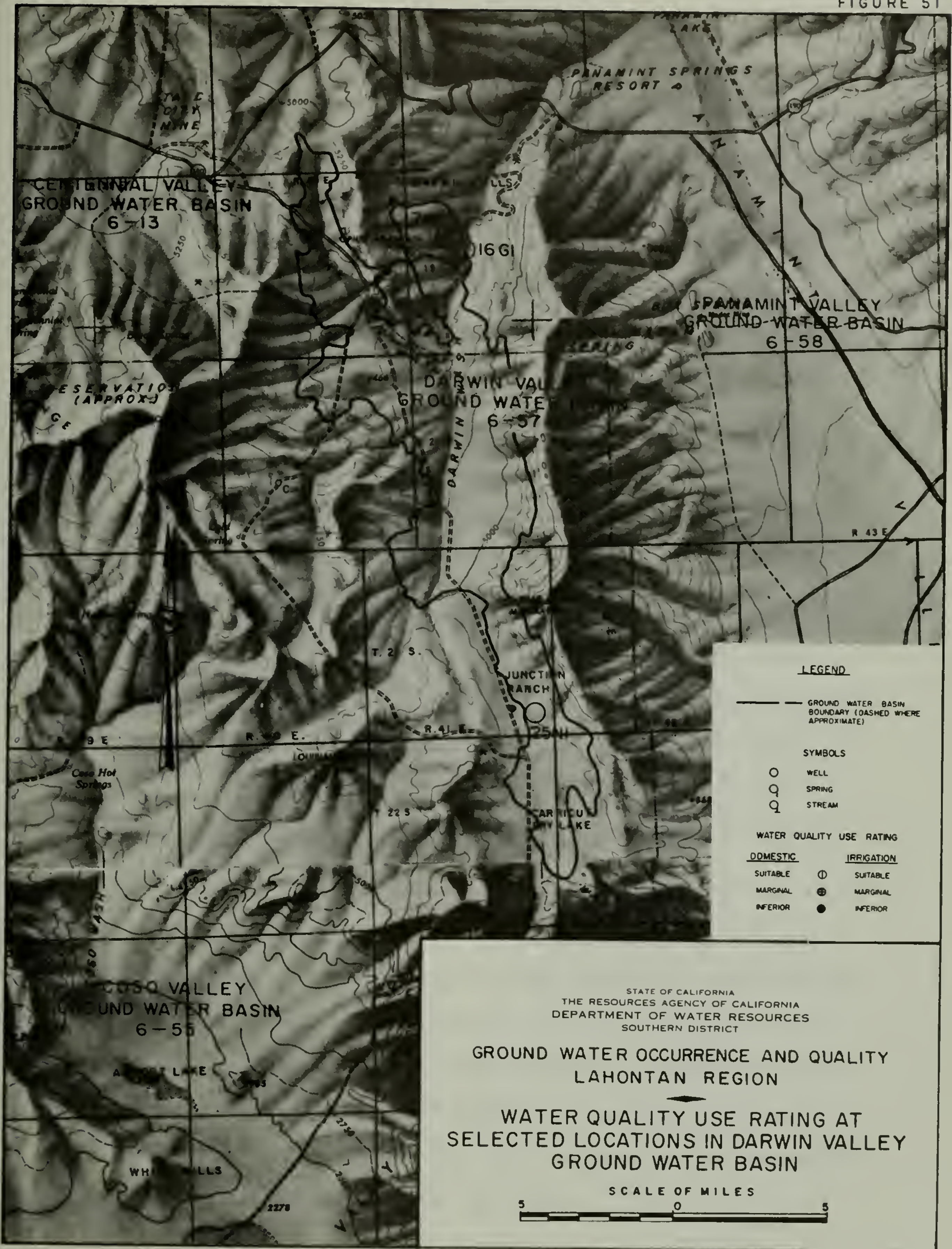
REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW AT SELECTED LOCATIONS IN

DARWIN VALLEY GROUND WATER BASIN (6-57)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
19S/41E-16G1	DI						Ca-Na HCO_3-SO_4	3-30-60	19.0	Mining Domestic
-17A1		DI		B, SO_4			Na-Ca SO_4-HCO_3	4- 9-54	15 ±	Mining
21S/41E-25N1								3- 7-54	242.5	Test

D - Domestic
I - Irrigation

FIGURE 51


PANAMINT SPRINGS RESORT
CENTENNIAL VALLEY GROUND WATER BASIN 6-13
PANAMINT VALLEY GROUND WATER BASIN 6-58
DARWIN VALLEY GROUND WATER BASIN 6-57
COSO VALLEY GROUND WATER BASIN 6-55
16G1
25N1
JUNCTION RANCH
Coso Hot Springs
T. 21 S.
T. 22 S.
R. 40 E.
R. 41 E.
R 43 E
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
MARGINAL
INFERIOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN DARWIN VALLEY
GROUND WATER BASIN
SCALE OF MILES
5
0
5

Panamint Valley Ground Water Basin (6-58)

Panamint Valley Ground Water Basin, shown on Figure 52 is a long, relatively narrow, northerly trending area of about 365 square miles located in the southern part of Inyo County, within the Searles Lake Drainage Basin (No. 21).

The basin is bordered on the north and east by the Panamint Range, on the west by the Argus Range, and on the south by the Slate Range. The Panamint Mountains on the east reach a maximum elevation of 11,049 feet and the Argus Mountains on the west reach a maximum of 8,839 feet. Elevations of the valley floor in the northern end of the basin rise to 2,800 feet, while those in the southern tip of the basin rise approximately to 1,400 feet.

Two dry lakes are located in the basin: Upper Panamint Lake in the northern portion of the valley, and Lower Panamint Lake in the southern part. Upper Panamint Lake occupies an area of 6.6 square miles and stands at an elevation of 1,542 feet. Lower Panamint Lake includes an area of 17.5 square miles and stands at an elevation of 1,021 feet. The dry lakes are separated by a ridge which rises gently to an elevation of 1,760 feet.

Geology

The Panamint Range to the north consists largely of pre-Tertiary granitic rocks; to the east, it consists predominantly of pre-Tertiary metamorphic rocks and Tertiary-Quaternary sediments. Pre-Tertiary granitic rocks, Paleozoic sediments, and Quaternary volcanic rocks occur in the Panamint Range to the east, as well as in the Slate Range to the south and southwest, and the Argus Range to the west.

Tertiary and/or Quaternary sediments occur in the foothills and in other parts of the basin. Quaternary alluvium is exposed over much of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 800 feet. Quaternary dune sand deposits occur in the northern part of the basin near Upper Panamint Lake, a dry type of playa. Lower Panamint Lake to the south is a moist, clay-encrusted type of playa. A series of faults, which roughly parallel the northerly trend of the basin, may act as barriers to ground water movement.

Water Supply

The sources of ground water replenishment to the basin are percolation of streamflow originating in the watershed and deep penetration of rainfall. The annual rainfall on the valley floor is about three or four inches; precipitation on the upper peaks of the Panamint Range may be as much as 12 inches. In addition to the drainage from the surrounding mountains, Brown Mountain Valley basin and portions of Darwin and Pilot Knob Valley basins drain to Panamint Valley basin. Runoff flows down numerous canyons or washes to the valley floor and then toward one of the dry lakes in irregular channels. Much of the water which reaches the valley floor is lost to evaporation.

The alluvial fans of the Argus, Panamint, and Slate Ranges are the main recharge areas and are probably capable of a high recharge rate. Subsurface inflow from Darwin basin enters Panamint basin by way of Darwin Wash; there may also be some subsurface inflow from Brown Mountain basin. Ground water in Recent and underlying older alluvium moves southerly toward the vicinity of Lower Panamint Lake.

Depth to water in the northern half of the basin is not known, but the presence of the dry lake indicates that the water table is more than 10 feet below the lakebed surface. However, the depth to water under Lower Panamint Lake, which is 500 feet lower in elevation than Upper Panamint Lake, is only three or four feet. A hydraulic gradient of about seven feet per mile exists in an east-west direction between well 21S/43E-25C1, and well 21S/44E-27M1.

Development and Utilization. People were first attracted to Panamint Valley by gold, silver, and copper strikes in the latter part of the 19th century. Rich discoveries of copper and silver near the head of Surprise Canyon in Panamint Range brought a population of 5,000 to Panamint City by 1874. This town was destroyed in 1876 by a summer cloudburst which flooded the canyon. The settlement of Ballarat at the base of the Panamint Mountains had several hundred occupants at that time and served as a general supply point for the mines throughout the adjacent area. About 60 people presently inhabit the valley.

In the 1890's several wells existed near Ballarat, however, these wells are now destroyed or are not in use. Well 21S/43E-25C1 was drilled in 1955 in the central portion of the valley for use in a mining operation. However, this well was used only a short time and was abandoned prior to 1960 because the mining operation ceased. As of 1960, all known wells in the basin still in existence were not in use since sufficient quantities of water were obtained from springs or surface flows.

About 100 acre-feet of water is used annually in the basin. The water from the springs and surface flows is used mainly for domestic purposes. An exception is the springs a few miles north of Ballarat, emanating from the base of the Panamint Mountains, which irrigate small areas of grass or pasture for stock grazing. The Panamint Springs Resort, located on Highway 190 at the northwest edge of the valley, uses water from Darwin Falls. These falls are the result of rising ground water which moves from Darwin Valley basin into Panamint Valley basin. Water is piped approximately 5-1/2 miles from the falls to the resort.

Water Quality. The most prominent water quality problem in the basin is the high sulfate concentration, as shown on Table 58. Twenty-two analyses show sulfate concentrations from 12 to 736 ppm with a mean of 268 ppm.

The ground water from well 22S/44E-4J1 near Ballarat and north to Sulfur Springs (21S/44E-10K1) is rated as inferior for domestic use due to fluoride and sulfate concentrations. These waters are also rated as suitable to inferior in quality for irrigation use because of the concentrations of chloride. Ground water in the vicinity of the dry lakes is probably mineralized to a higher degree than that found on the higher slopes away from the lakebed. In 1955, ground water in the central part of the valley from well 21S/43E-25C1, had a total dissolved solids content of 782 ppm and was rated as suitable for irrigation or domestic purposes. Since that time, however, bailed samples of water from this well indicate that the total dissolved solids content has increased to 1,150 ppm. This water has a sodium-calcium chloride character.

Water from springs in the surrounding mountains is rated from suitable to inferior in quality for domestic purposes. The total dissolved solids content of these springs ranges from 158 to 1,995 ppm and averages 732 ppm. Water from springs which contains moderately high concentrations of sulfate has been rated as marginal or inferior for domestic uses. Most springs on the east side of the basin have a calcium sulfate character, whereas the other springs in the basin have varied character.

The water from Darwin Falls (19S/41E-3D1) in the northwest end of the valley is rated as marginal for domestic use because it has a fluoride concentration of 1.2 ppm.

TABLE 58

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
PANAMINT VALLEY GROUND WATER BASIN (6-58)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior			Date	feet or cfs	
Darwin Wash 18S/41E-36K1		I	D	B, SO_4	F		Ca-Na SO_4	4-18-56	flow	--
Darwin Falls 19S/41E-3D1	I	D		F		5.5 ± 2.0	Ca-Na HCO_3	11-20-59	flow	Domestic
French Madam Spring 19S/42E-31M1	DI						Ca HCO_3-SO_4	4-19-56	flow	Unknown
Box Spring -32E1	DI						Ca HCO_3	4- 9-54	flow	Domestic Mining
Wildrose Spring 19S/44E-21Q1	I	D		SO_4			Ca SO_4	4-19-56	flow	Domestic
19S/45E-35P1	DI						Ca HCO_3	4-10-54	flow	Domestic
20S/44E-10D1	I	D		SO_4, TDS			Ca SO_4	4-10-54	flow	Mining
Jail Canyon Spring -14K1	DI						Ca SO_4	4-19-56	flow	Unknown
21S/43E-25C1		DI		EC, TDS, Cl			Na-Ca Cl	4-20-61	64.0	Unused

D - Domestic
I - Irrigation

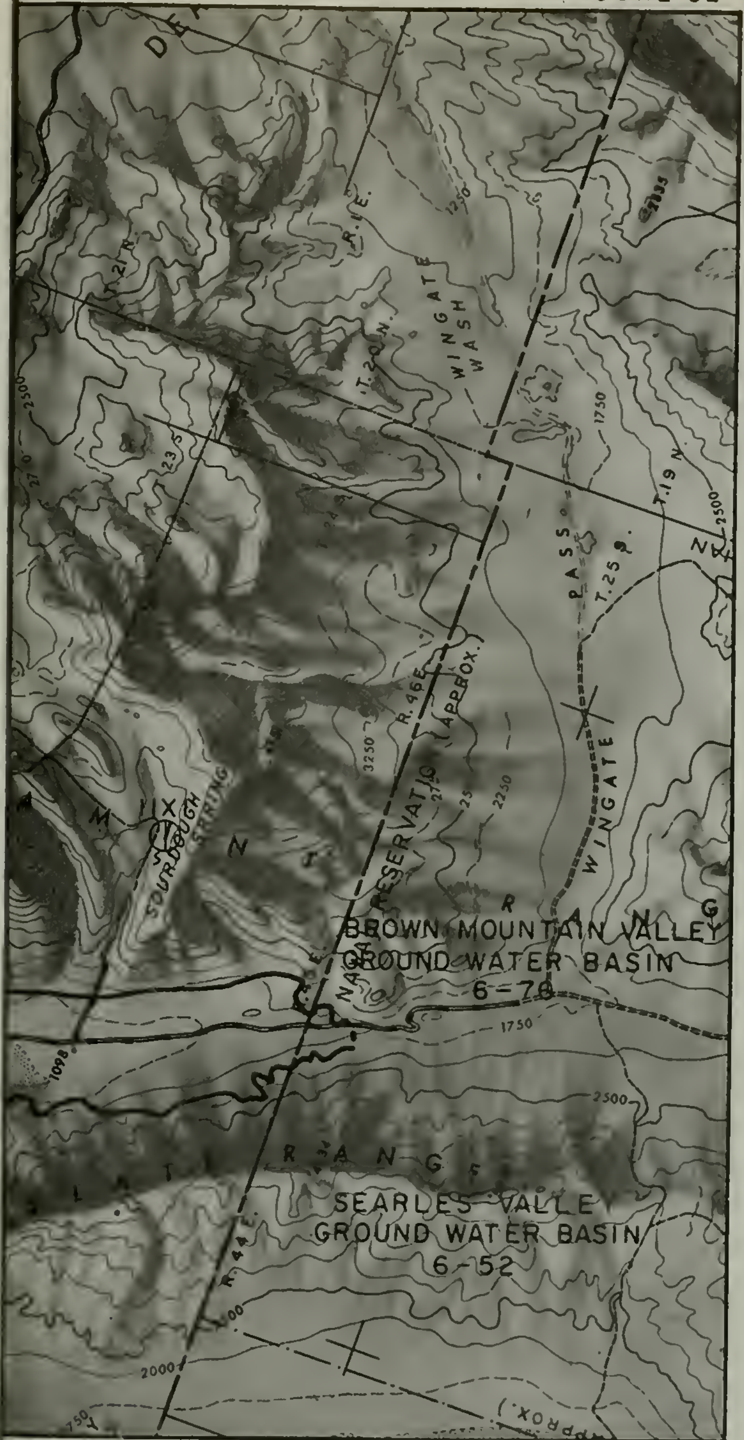
TABLE 58

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
PANAMINT VALLEY GROUND WATER BASIN (6-58)
(continued)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Warm Sulfur Spring 21S/44E-10K1			DI	SO_4, B, TDS	EC, Cl, F % Na		Na Cl	2-10-55	flow	Unknown
-27M1	I		D		F		Na-Ca SO_4	3-31-60	42.0	Unused
Cliff Spring 21S/45E-17B1	DI						Ca HCO_3	4-11-55	flow	Unknown
Ballarat 22S/44E-4J1		I	D	EC,	SO_4, Cl, TDS		Na-Ca SO_4-Cl	3-18-54	21.5	Unused
Post Office Spring _9A1		I	D	EC, Cl, TDS	SO_4		Na Cl-SO_4	2-10-55	3.4	Domestic
Colter Spring 45E-29X1	I	D		SO_4			Ca SO_4	4-10-55	flow	Unknown
Redlands Spring 23S/45E-18X1	I	D		SO_4			Ca SO_4	4-10-53	flow	Unknown
Sourdough Spring 24S/45E-11X1	DI						Na-Ca HCO_3-SO_4	4-10-56	flow	Unknown

D - Domestic
I - Irrigation

FIGURE 52



STATE OF CALIFORNIA
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DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

UND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT
TED LOCATIONS IN PANAMINT VALLEY
GROUND WATER BASIN

SCALE OF MILES
5 0 5

LEGEND

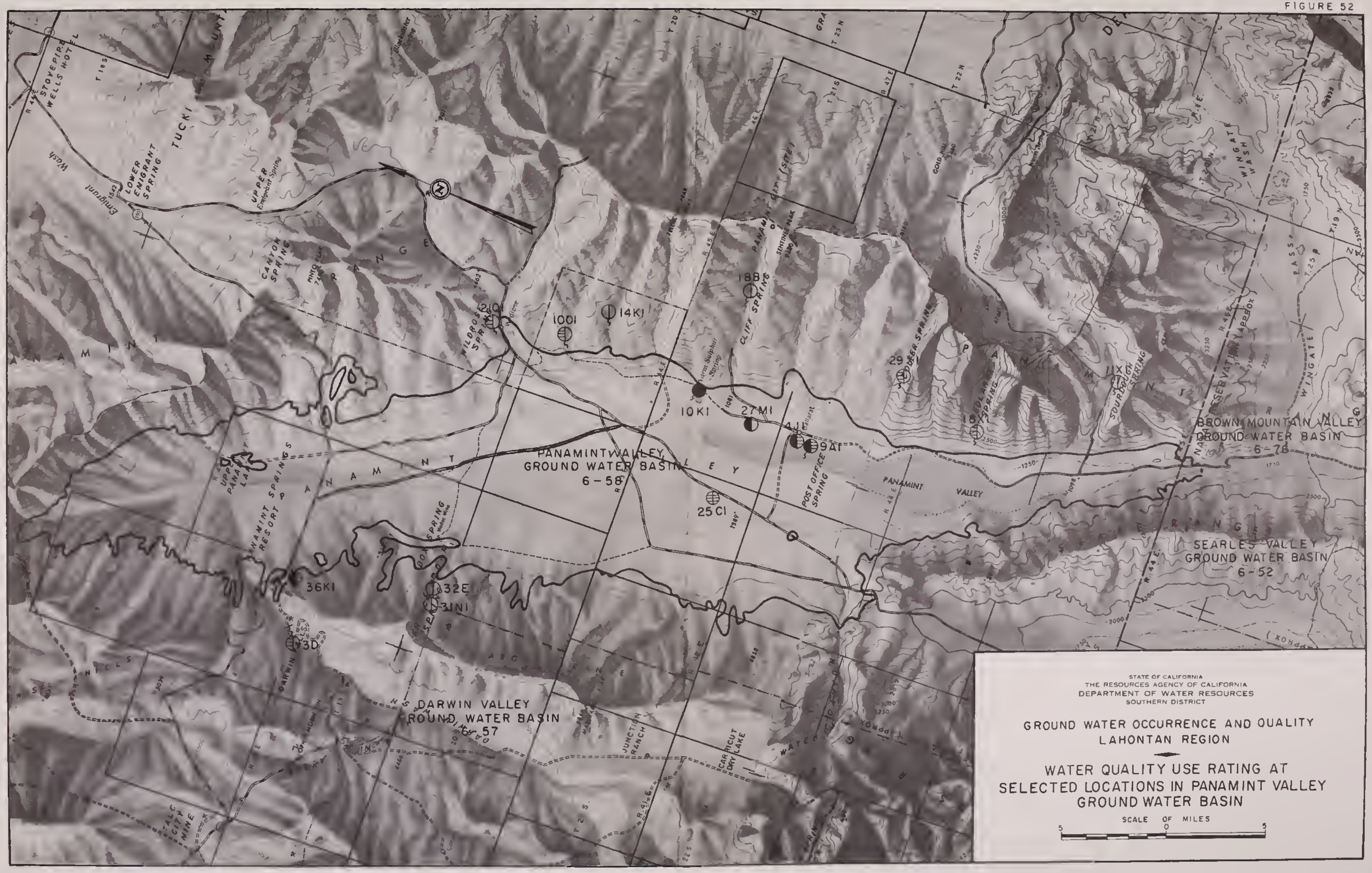
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE

SYMBOLS

○	WELL
	SPRING
	STREAM

WATER QUALITY USE RATING

DOMESTIC		IRRIGATION
SUITABLE		SUITABLE
MARGINAL		MARGINAL
INFERIOR	●	INFERIOR



STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN PANAMINT VALLEY GROUND WATER BASIN

SCALE OF MILES
5 0 5

Kelso Landers Valley Ground Water Basin (6-69)

Kelso Landers Valley Ground Water Basin, shown on Figure 53, is an elliptically shaped northwesterly trending area of about 17 square miles located in the east portion of Kern County, within the Searles Lake Drainage Basin (No. 21).

This basin is completely encircled by the Sierra Nevada whose peaks in this area rise to elevations of 7,700 feet. Elevations of the basin floor range from about 3,600 feet in the southern end, to 5,000 feet in the northern portion of the basin.

Geology

The basin, which forms a slight depression in the Sierra Nevada, is surrounded on all sides by pre-Tertiary granitic rocks except for the southeast corner which consists of Paleozoic sediments.

Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 125 feet.

Water Supply

The principal source of ground water replenishment in the Kelso Landers Valley Ground Water Basin is percolation of streamflow originating in the watershed. The valley floor receives an annual rainfall of six or seven inches. Large quantities of runoff are drained from the basin by way of Cottonwood Creek which originates on the northwest side of the basin. This creek passes out of the basin through its southern end into Jawbone Canyon which drains toward Fremont Valley basin.

Kelso Landers Valley Ground Water Basin (6-69)

Kelso Landers Valley Ground Water Basin, shown on Figure 53, is an elliptically shaped northwesterly trending area of about 17 square miles located in the east portion of Kern County, within the Searles Lake Drainage Basin (No. 21).

This basin is completely encircled by the Sierra Nevada whose peaks in this area rise to elevations of 7,700 feet. Elevations of the basin floor range from about 3,600 feet in the southern end, to 5,000 feet in the northern portion of the basin.

Geology

The basin, which forms a slight depression in the Sierra Nevada, is surrounded on all sides by pre-Tertiary granitic rocks except for the southeast corner which consists of Paleozoic sediments.

Quaternary alluvium is exposed over most of the basin floor. The alluvium comprises the upper portion of the valley fill which extends to a depth of at least 125 feet.

Water Supply

The principal source of ground water replenishment in the Kelso Landers Valley Ground Water Basin is percolation of streamflow originating in the watershed. The valley floor receives an annual rainfall of six or seven inches. Large quantities of runoff are drained from the basin by way of Cottonwood Creek which originates on the northwest side of the basin. This creek passes out of the basin through its southern end into Jawbone Canyon which drains toward Fremont Valley basin.

The alluvial fans fringing the basin are considered to be the recharge areas and are probably capable of a moderate recharge rate. Ground water in Recent and underlying older alluvial deposits, moves to the south, probably passing across the basin boundary into Fremont Valley basin. Depth to water ranges from 125 feet at well 29S/35E-8K1 to flowing conditions at well 29S/35E-21K1.

Development and Utilization. Development in the basin has been mainly stock ranching. Some land has been cleared and irrigated in the past but at present there is no irrigated area in the valley. All wells are windmill powered and are utilized for stock or domestic purposes. Most of these wells are in the southern half of the basin where ground water is found at shallower depths. It is estimated that about five acre-feet of ground water is annually extracted from the basin.

Water Quality. As shown on Figure 53 and Table 59, the ground water of this basin is considered to be marginal to inferior for domestic use due to fluoride concentrations that vary from 0.9 to 2.3 ppm and average 1.5 ppm. However, this water is suitable for stock because fluoride concentrations of this level have no known detrimental effects on cattle. With the exception of water from well 29S/35E-33H1, which is rated as marginal, the ground water is also rated as suitable for irrigation use. The total dissolved solids content of the ground water ranges from 361 to 1,300 ppm and the character of the water is variable.

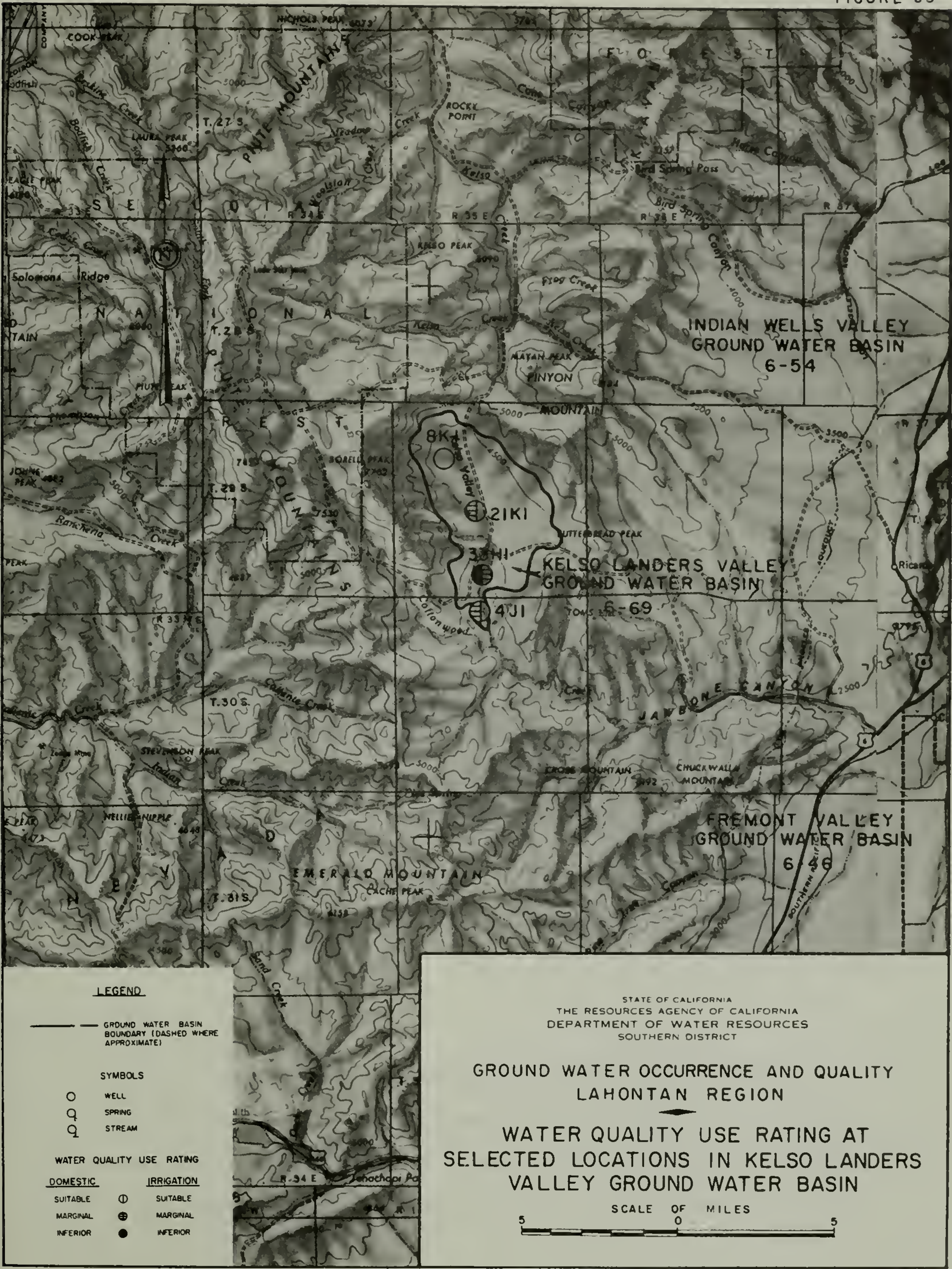
TABLE 59

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
KELSO LANDERS VALLEY GROUND WATER BASIN (6-69)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
29S/35E-21K1	I	D		F			Ca-Na HCO_3	8-28-60	flow	Domestic
29S/35E-33H1		I	D	EC, SO_4, TDS	F		Na HCO_3-SO_4			Stock
30S/35E-4J1	I	D		F			Na-Ca HCO_3	7-13-55	12.0	Domestic

D - Domestic
I - Irrigation

FIGURE 53



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GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

WATER QUALITY USE RATING AT SELECTED LOCATIONS IN KELSO LANDERS VALLEY GROUND WATER BASIN

Brown Mountain Valley Ground Water Basin (6-76)

Brown Mountain Valley Ground Water Basin, shown on Figure 54, is a small northerly trending area of about 32 square miles, located in the northwest portion of San Bernardino County, within the Searles Lake Drainage Basin (No. 21).

This basin is bordered by the Panamint Range on the northeast, and by the Slate Range on the south and southwest. Brown Mountain rises to an elevation of 5,131 feet; several peaks in the Slate Range exceed 5,000 feet in elevation. The valley floor ranges in elevation from 1,630 feet at the northern limits of the basin to about 2,800 feet along its east and west sides.

Geology

The Panamint Range to the northeast consists of a variety of rock types including pre-Tertiary granitic and Tertiary-Quaternary volcanic rocks. Tertiary volcanic rocks occur to the east in the Brown Mountain area. The Slate Range to the south and west consists of pre-Tertiary granitic and metamorphic rocks and to the northwest of Tertiary-Quaternary volcanic rocks. Quaternary alluvium, which is exposed over much of the basin floor, comprises the upper portion of the valley fill.

Water Supply

The principal source of ground water replenishment in Brown Mountain Valley Ground Water Basin is percolation of streamflow originating in the watershed. The valley annually receives about 5 inches of rainfall. Runoff from the watershed flows toward the central axis of the basin and then northward into Panamint Valley basin. Although Pilot Knob Valley basin to the south drains into Brown Mountain Valley basin, the stream channels are normally dry and Brown Mountain Valley basin receives very little inflow from that source.

The alluvial fans extending from the Slate Range and from Brown Mountain are considered to be the recharge areas, and recharge probably occurs at a moderate rate. Ground water in the Recent and underlying older alluvial deposits moves to the north. There may be some subsurface inflow from Pilot Knob basin and some subsurface outflow to Panamint Valley basin. A buried bedrock ridge at the northern end of Brown Mountain Valley basin may act as a partial barrier to ground water outflow.

Development and Utilization. Mining activities in the Slate Range constitute the only development in the valley other than activities that may take place on the Naval Reservation. No wells are known to exist in the basin and all water is obtained from springs on the west side of the basin. During the late 1800's a stage station existed near Lone Willow Spring (26S/45E-21X1) and water was piped from the spring to the station. The "Twenty Mule Teams" used this station as a watering point when they hauled borax from Death Valley to Mojave. The station has long since been destroyed and the spring is now marked on topographic maps of the area as containing undrinkable water.

Water Quality. Samples from Lone Willow Spring (26S/45E-21X1) and Early Spring (26S/45E-22X1) were collected in 1918. As shown on Table 60, the analyses indicated that the quality was suitable for domestic and irrigation uses; however, fluoride and boron were not determined. The total dissolved solids content in water from Lone Willow Spring was 962 ppm, water from Early Spring had a total solids content of 652 ppm.

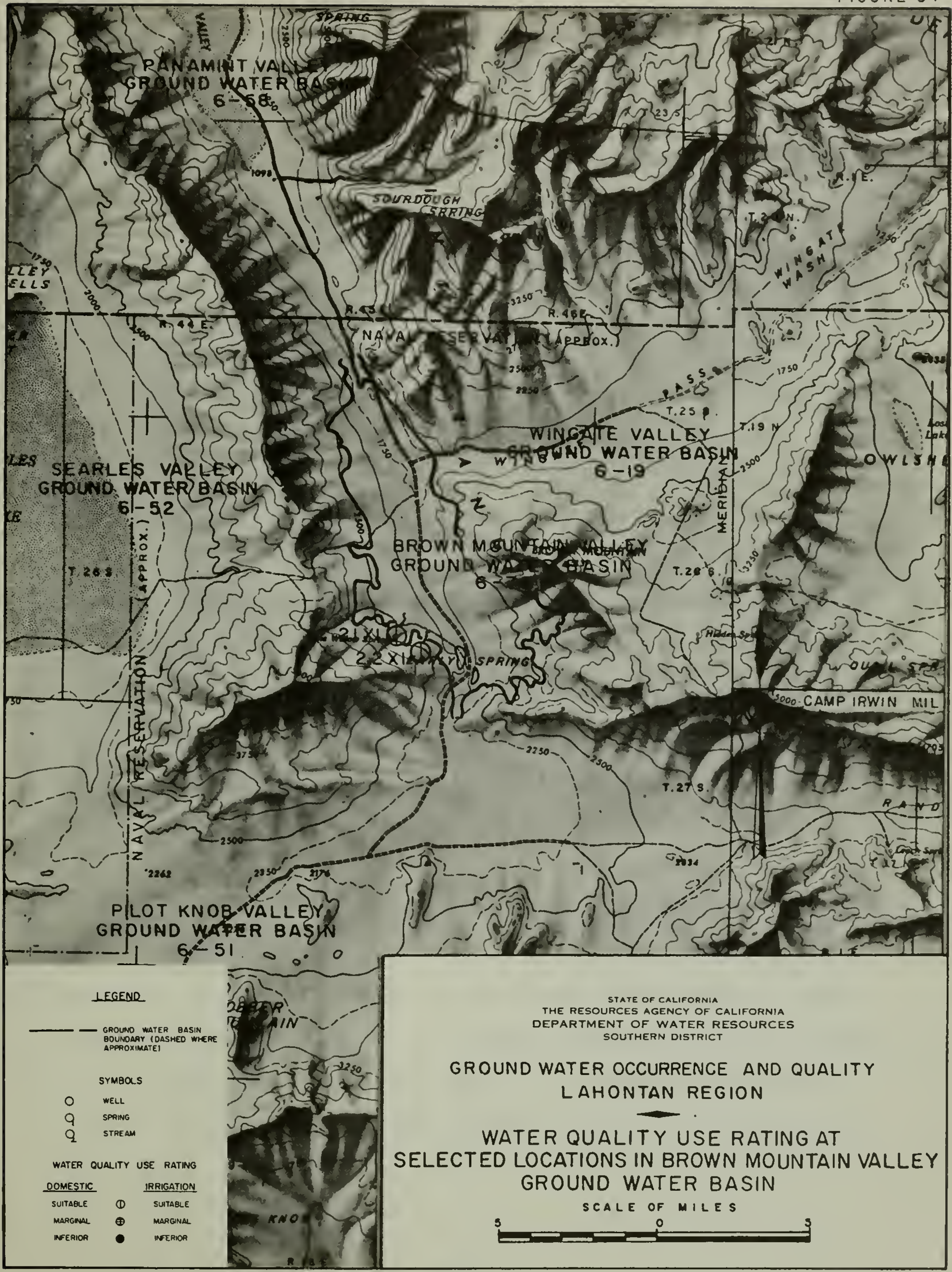
TABLE 60

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
BROWN MOUNTAIN VALLEY GROUND WATER BASIN (6-76)

Location of Sampling Point and/or Well Number	Water Quality Use Rating: Classification: Suitable	Classification: Marginal	Classification: Inferior	Basis for Classification: Marginal	Basis for Classification: Inferior	Total radioactivity and standard deviation picocuries/ltr	Character	Depth to water or rate of flow: Date	Depth to water or rate of flow: feet or cfs	Use
Lone Willow Spring * 26S/45E-21X1	DI						Na-Ca HCO_3-Cl	1-11-18	flow	Domestic
Early Spring * 26S/45E-22X1	DI						Ca HCO_3	1-11-18	flow	Domestic

D - Domestic
I - Irrigation
* Floride, Boron not determined.

FIGURE 54


PANAMINT VALLEY GROUND WATER BASIN 6-58
SOURDOUGH SPRING
WINGATE WASH
NAVAL RESERVATION (APPROX.)
WINGATE VALLEY GROUND WATER BASIN 6-19
SEARLES VALLEY GROUND WATER BASIN 6-52
BROWN MOUNTAIN VALLEY GROUND WATER BASIN
NAVAL RESERVATION (APPROX.)
CAMP IRWIN MIL
PILOT KNOB VALLEY GROUND WATER BASIN 6-51
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
SUITABLE
MARGINAL
MARGINAL
INFERIOR
INFERIOR
STATE OF CALIFORNIA
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DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT SELECTED LOCATIONS IN BROWN MOUNTAIN VALLEY GROUND WATER BASIN
SCALE OF MILES
5
0
5

Grass Valley Ground Water Basin (6-77)

Grass Valley Ground Water Basin, shown on Figure 55, is a small irregularly shaped area of about 29 square miles, located in the western part of San Bernardino County, within Searles Lake Drainage Basin (No. 21).

The basin is bounded on the north and west by low hills, by Slocum Mountain on the east, and by the Gravel Hills on the south. Slocum Mountain attains a maximum elevation of 5,124 feet; the valley floor ranges in elevation from 3,200 feet at the southeast corner to 3,800 feet on the north.

Geology

Pre-Tertiary granitic rocks occur in the hills to the west and north and in the Slocum Mountains area to the east. The Gravel Hills to the south consist of pre-Tertiary granitic rocks and Tertiary sediments. Alluvial divides also occur to the east and west between the basin and adjoining areas. Quaternary alluvium, which is exposed over much of the basin floor, comprises the upper portion of the valley fill.

Water Supply

The principal source of ground water replenishment in the Grass Valley Ground Water Basin is percolation of streamflow originating in the watershed. The annual rainfall is approximately seven inches. Surface flow in the valley is limited to the runoff from the surrounding mountains, most of which drains down a single wash in the southern portion of the valley. This wash drains to the south through Black Canyon into Harper Valley basin.

Ground water in the Recent and underlying alluvial deposits probably moves towards the south. The depth to water in 1955 at well 30S/44E-35E1, the only known well in the basin, was 86.1 feet.

Development and Utilization. The United States Naval Reservation covers most of the basin. Part of the land is leased for grazing and well 30S/44E-35E1 is used for the watering of stock. The estimated ground water extraction of the basin is less than two acre-feet per year. There are no known inhabitants in the basin area.

Ground Water Quality. The water at well 30S/44E-35E1 has a total dissolved solids content of 473 ppm and is suitable for both domestic and irrigation uses, as shown on Table 61. The ground water throughout the valley is probably similar in quality. The general character of the water from this well is sodium chloride-sulfate.

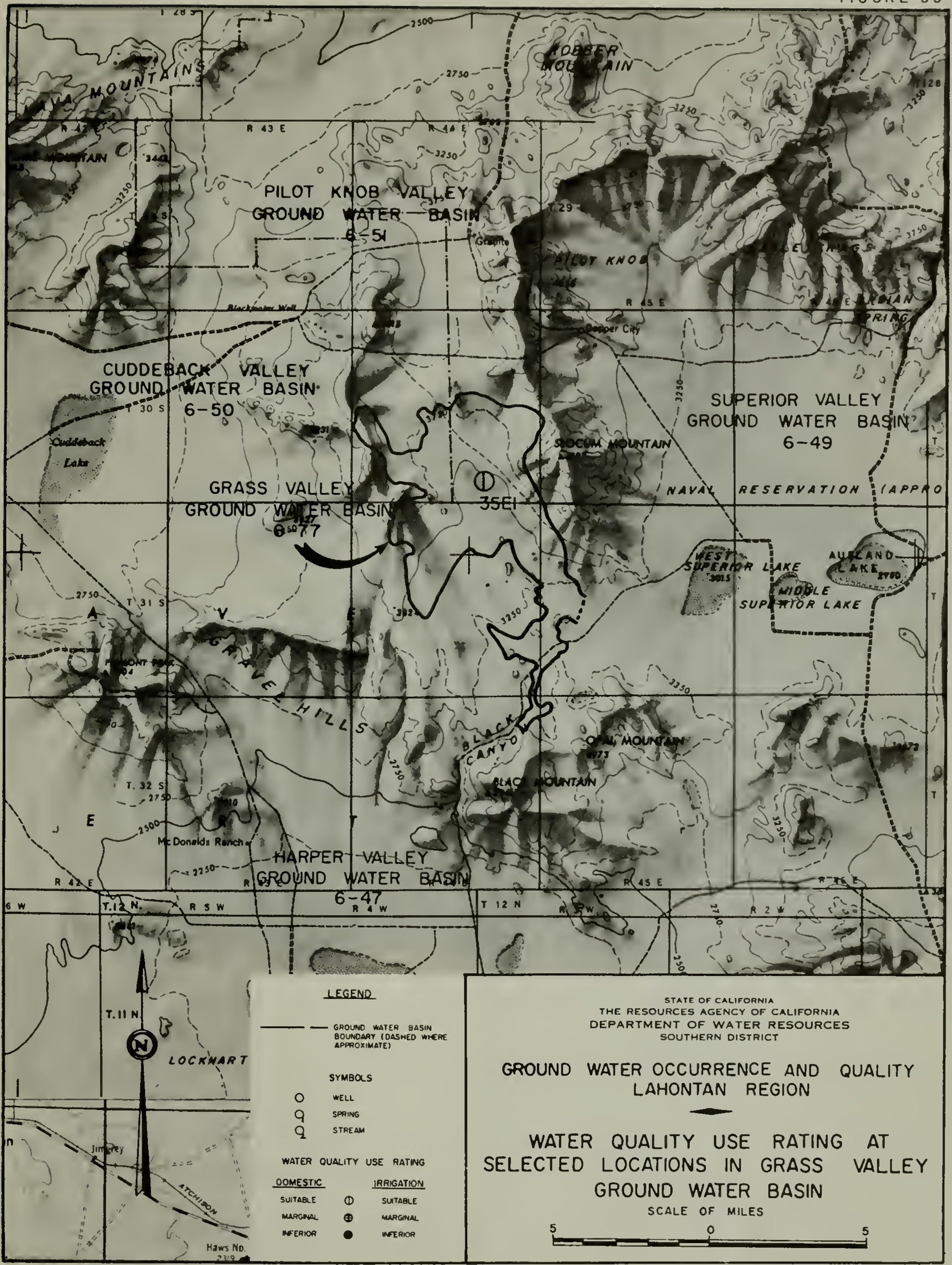
TABLE 61

REPRESENTATIVE WATER QUALITY DATA AND DEPTH TO WATER OR RATE OF FLOW
AT SELECTED LOCATIONS IN
GRASS VALLEY GROUND WATER BASIN (6-77)

Location of Sampling Point and/or Well Number	Water Quality Use Rating					Total radioactivity and standard deviation	Character	Depth to water or rate of flow		Use
	Classification			Basis for Classification						
	Suitable	Marginal	Inferior	Marginal	Inferior	picocuries/ltr		Date	feet or cfs	
Central 30S/44E-35E1	DI					11.1 ± 2.1	Na Cl-SO_4	5-8-55	86.1	Stock

D - Domestic
I - Irrigation

FIGURE 55


PILOT KNOB VALLEY
GROUND WATER BASIN
6-51
CUDDEBACK VALLEY
GROUND WATER BASIN
6-50
SUPERIOR VALLEY
GROUND WATER BASIN
6-49
GRASS VALLEY
GROUND WATER BASIN
6-77
35E1
HARPER VALLEY
GROUND WATER BASIN
6-47
ROBBER MOUNTAIN
PILOT KNOB
SLOCUM MOUNTAIN
NAVAL RESERVATION (APPRO
WEST SUPERIOR LAKE
MIDDLE SUPERIOR LAKE
GRAVEL HILLS
BLACK CANYON
OPAL MOUNTAIN
BLACK MOUNTAIN
Cuddeback Lake
Blackwater Well
Copper City
McDonalds Ranch
LOCKHART
ATCHISON
R 43 E
R 44 E
R 45 E
R 42 E
T 30 S
T 31 S
T. 32 S
T 12 N
T. 11 N.
R 4 W
R 2 W
LEGEND
GROUND WATER BASIN BOUNDARY (DASHED WHERE APPROXIMATE)
SYMBOLS
WELL
SPRING
STREAM
WATER QUALITY USE RATING
DOMESTIC
IRRIGATION
SUITABLE
MARGINAL
INFERIOR
STATE OF CALIFORNIA
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SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
WATER QUALITY USE RATING AT
SELECTED LOCATIONS IN GRASS VALLEY
GROUND WATER BASIN
SCALE OF MILES
5
0
5

LOCATION MAP

115° 30'

116° 00'

116° 30'

LEGEND

REGION BOUNDARY

DRAINAGE BASIN BOUNDARY AND NUMBER

GROUND WATER BASIN

M SAN BERNARDINO BASE AND MERIDIAN

M MT DIABLO BASE AND MERIDIAN

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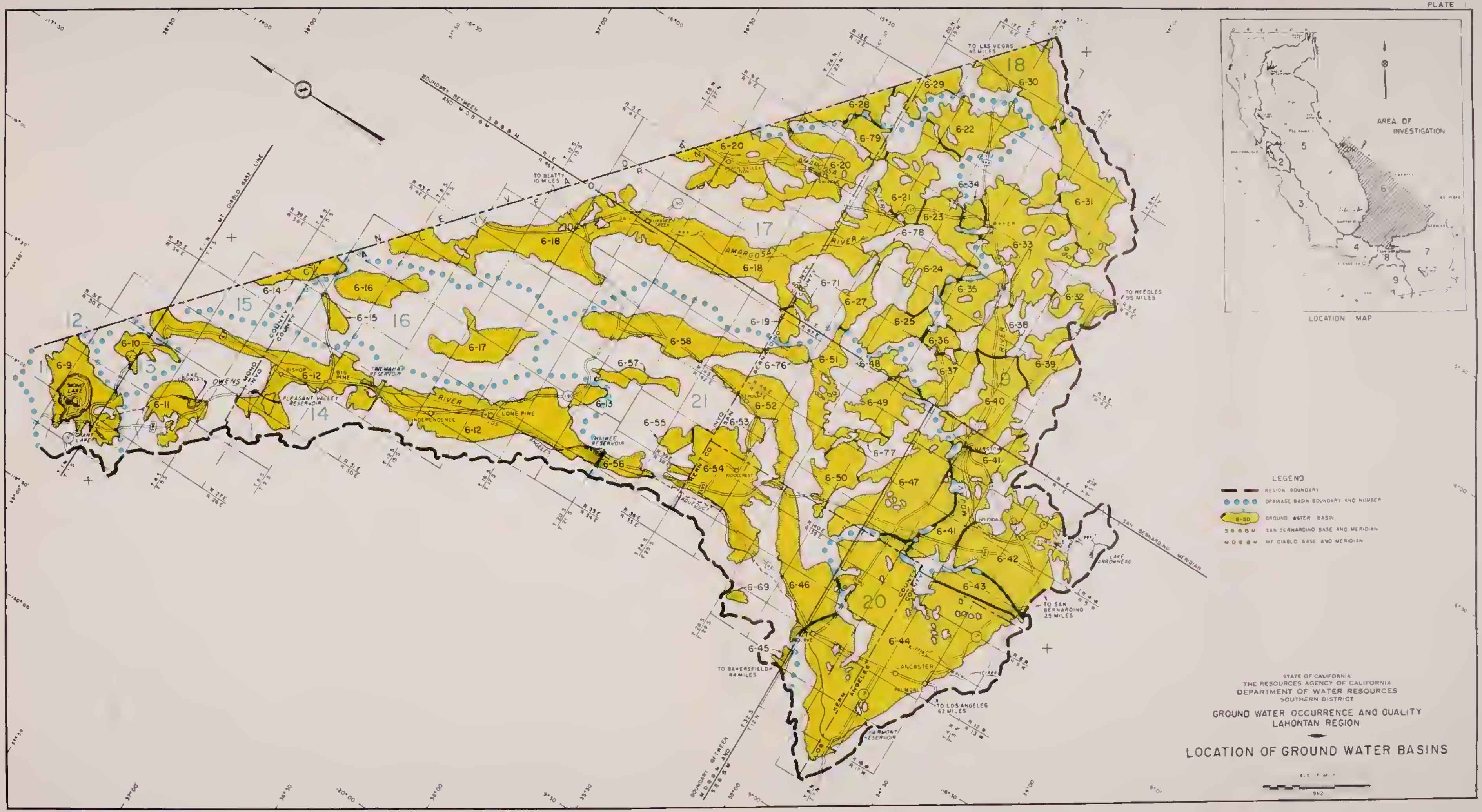
WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

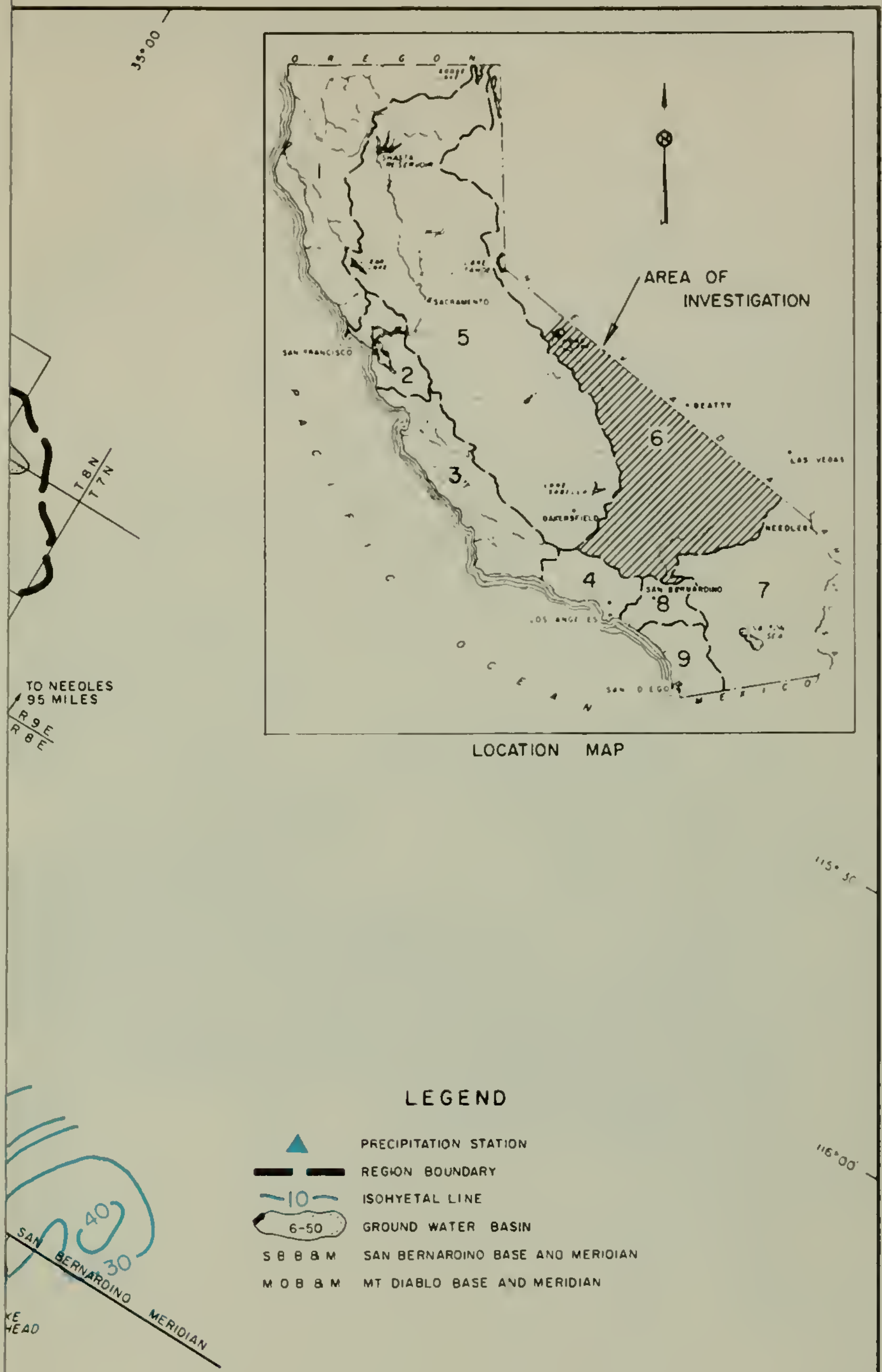
OF GROUND WATER BASINS

SCALE OF MILES

1962

Drainage Basin and Number	Basin and Number	
Mono Lake (No. 11)	6-9	Mono Lake Valley
Huntoon (No. 12)		None in California
Adobe (No. 13)	6-10	Adobe Valley
Owens River (No. 14)	6-11	Long Valley
	6-12	Owens Valley
	6-13	Centennial Valley
Cottonwood Creek (No. 15)	6-14	Fish Lake Valley
Deep Springs (No. 16)	6-15	Deep Springs Valley
	6-16	Eureka Valley
	6-17	Saline Valley
Amargosa River (No. 17)	6-18	Death Valley
	6-19	Wingate Valley
	6-20	Amargosa Valley
	6-21	Valjean Valley
	6-22	Shadow Valley
	6-23	Riggs Valley
	6-24	Red Pass Valley
	6-25	Bicycle Valley
	6-27	Leach Valley
	6-71	Lost Lake Valley
	6-78	Denning Spring Valley
	6-79	California Valley
Ivanpah Valley (No. 18)	6-28	Pahrump Valley
	6-29	Mesquite Valley
	6-30	Ivanpah Valley
Mojave River (No. 19)	6-31	Kelso Valley
	6-32	Broadwell Valley
	6-33	Soda Lake Valley
	6-34	Silver Lake valley
	6-35	Cronise Valley
	6-36	Langford Valley
	6-37	Coyote Lake Valley
	6-38	Caves Canyon Valley
	6-39	Troy Valley
	6-40	Lower Mojave River Valley
	6-41	Middle Mojave River Valley
	6-42	Upper Mojave River Valley
Antelope (No. 20)	6-43	El Mirage Valley
	6-44	Antelope Valley
Searles Lake (No. 21)	6-45	Proctor Valley
	6-46	Fremont Valley
	6-47	Harper Valley
	6-48	Goldstone Valley
	6-49	Superior Valley
	6-50	Cuddeback Valley
	6-51	Pilot Knob Valley
	6-52	Searles Valley
	6-53	Salt Wells Valley
	6-54	Indian Wells Valley
	6-55	Coso Valley
	6-56	Rose Valley
	6-57	Darwin Valley
	6-58	Panamint Valley
	6-69	Kelso Landers Valley
	6-76	Brown Mountain Valley
	6-77	Grass Valley





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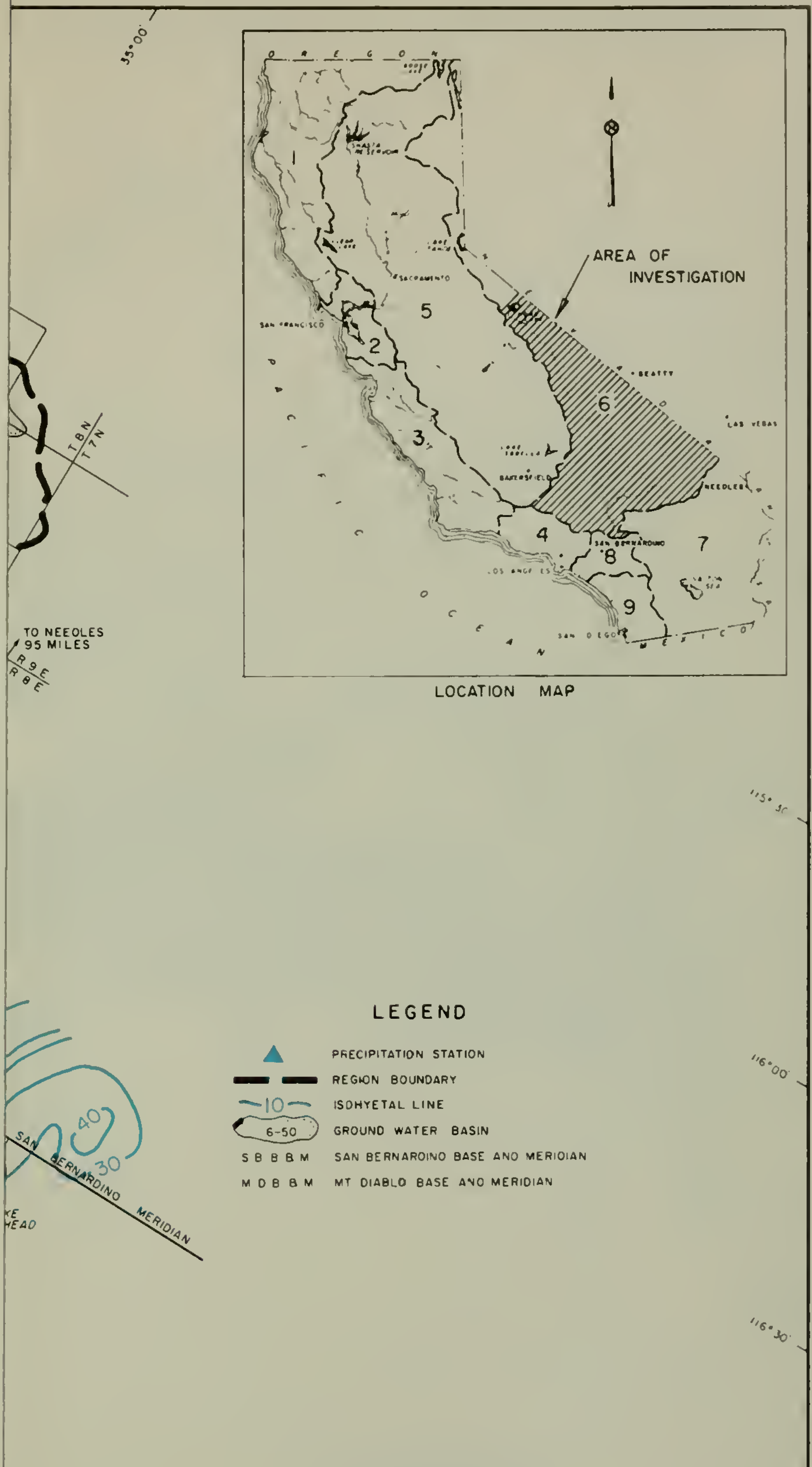
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

GEOGRAPHICAL DISTRIBUTION OF PRECIPITATION

962



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GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION

GEOGRAPHICAL DISTRIBUTION OF PRECIPITATION

SCALE OF MILES

962

PLATE 2

LOCATION MAP
AREA OF INVESTIGATION
LEGEND
PRECIPITATION STATION
REGION BOUNDARY
ISOHYETAL LINE
GROUND WATER BASIN
S B B & M SAN BERNARDINO BASE AND MERIDIAN
M D B & M MT DIABLO BASE AND MERIDIAN
BOUNDARY OF INVESTIGATION
BOUNDARY BETWEEN S B B & M AND M D B & M
MT DIABLO BASE LINE
SAN BERNARDINO MERIDIAN
TO LAS VEGAS 43 MILES
TO BEATTY 10 MILES
TO NEEDLES 95 MILES
TO SAN BERNARDINO 25 MILES
TO LOS ANGELES 62 MILES
TO BAKERSFIELD 44 MILES
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DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
GROUND WATER OCCURRENCE AND QUALITY
LAHONTAN REGION
GEOGRAPHICAL DISTRIBUTION
OF PRECIPITATION

APPENDIX A

DEFINITION OF TERMS

APPENDIX A

DEFINITION OF TERMS

APPENDIX A

DEFINITION OF TERMS

The following terms are defined as used in this report.

Anticline - A fold in rocks in which the strata dip in opposite directions from a common ridge or axis, like the roof of a house.

Aquifer - A formation or part of a formation which transmits water in sufficient quantity to supply pumping wells or springs.

Artesian Well - Any artificial opening in the ground through which water naturally flows from subterranean sources to the surface of the ground.

Character of Water - A classification of water based on determination of the predominant anions and cations in equivalents per million (epm). Specifically, the name of an ion is used where its chemical equivalent constitutes one-half or more of the total ions for its appropriate group. For example, sodium chloride water is water in which the sodium is equal to or greater than 50 percent of the cations; sodium calcium chloride water is water in which the sodium is more abundant than the calcium, but is less than 50 percent of the total cations; and sodium chloride-sulphate water is water in which chloride exceeds sulphate but is less than 50 percent of the total anions.

Confined Ground Water - A body of ground water overlain by material sufficiently impervious to sever free hydraulic connection with overlying ground water except at the intake. Confined ground water moves in conduits under pressure due to the difference in head between the intake and discharge areas of the confined water body.

Connate Water - Water entrapped in the interstices of a sedimentary rock at the time it was deposited. This water may be fresh, brackish, or saline in character. Because of the dynamic geologic and hydrologic conditions in California this definition has been altered in practice to apply to water in older formations, even though the water in these formations may have been altered in quality since the rock was deposited.

Contamination - Defined in Section 13005 of the California Water Code: "an impairment of the quality of the waters of the State by sewage or industrial waste to a degree which creates an actual hazard to public health through poisoning or through the spread of disease. . . ." Jurisdiction over matters regarding contamination rests with the State Department of Public Health and local health officers.

Degradation - Impairment of the quality of water due to causes other than disposal of sewage and industrial waste.

Deterioration - An impairment of water quality.

Evapotranspiration - That portion of the precipitation returned to the atmosphere through direct evaporation or by transporation of vegetation.

Equivalents Per Million (epm) - Equivalent weights of solute contained in one million parts by weight of solution. For practical purposes, epm is the same as milliquivalents per liter.

Free Ground Water - Water in interconnected interstices in the zone of saturation down to the first impervious barrier, moving under the control of the water-table slope.

Ground Water - That part of the subsurface water in the zone of saturation.

Ground Water Basin - As used herein, is defined as an area underlain by water-bearing sediments capable of storing and yielding a ground water supply.

Hydraulic Gradient - Under unconfined ground water conditions, it is the slope of the profile of the water table. Under confined ground water conditions, it is the slope of the line joining the elevations to which water would rise in wells perforated in a confined aquifer.

Impairment - A change in quality of water which decreases its suitability for beneficial use.

Industrial Waste - Defined in Section 13005 of the California Water Code: "any and all liquid or solid water substance, not sewage, from any producing, manufacturing or processing operation of whatever nature."

Mineral Analysis - The quantitative determination of inorganic impurities or dissolved mineral constituents in water.

Perched Ground Water - Ground water occurring in the saturated upper zone separated from the main ground water body by impervious material.

Overdraft - The average annual decrease in the amount of ground water in storage that occurs during a long time period, under a particular set of physical conditions affecting the supply, use, and disposal (including extractions) of water in the ground water basin.

Parts Per Million (ppm) - One part of solute per million parts of solution by weight at 20°C.

Percolation - The movement of water through the interstices of a soil or other porous media.

Permeability - The ability of a rock to transmit a fluid. The degree of permeability depends upon the size and shape of the pores, and upon the size, shape, and extent of the pore interconnections.

Playa - A nearly level portion of a desert basin in which water collects and evaporates. The playa is characterized by the accumulation of fine-grained sediments and/or salts.

Pollution - Defined in Section 13005 of the California Water Code: "an impairment of the quality of the waters of the State by sewage or industrial waste to a degree which does not create an actual hazard to the public health but which does adversely and unreasonably affect such waters for domestic, industrial, agricultural, navigational, recreational or other beneficial use, or which does adversely and unreasonably affect the ocean waters and bays of the State devoted to public recreation." Regional Water Pollution Control Boards are responsible for prevention and abatement of pollution.

Pressure Area - A ground surface area underlain by an aquifer containing confined ground water.

Recharge - The process of replenishment of the ground water reservoir through natural or artificial means.

Safe Yield - The average annual amount of ground water that could be extracted from a ground water basin over a long time period which would not affect a long time net change in storage of ground water; the extractions must occur under a particular set of physical conditions affecting the water supply, use, and disposal of water in the ground water basin.

Saturation, Zone Of - The zone below the water table in which all interstices are filled with ground water.

Sewage - Defined in Section 13005 of the California Water Code: "any and all waste substance, liquid or solid, associated with human habitation, or which contains or may be contaminated with human or animal excreta or excrement, offal, or any feculent matter." As used in this report, sewage is included as part of the waste waters carried by community sewer systems.

Syncline - A fold in rocks in which the strata dip inward from both sides toward a common axis, like the inverted roof of a house.

Total Dissolved Solids (TDS) - The dry residue from the dissolved matter in an aliquot of a water sample remaining after evaporating the sample at a definite temperature.

Total Radioactivity - The combination of alpha, beta, and gamma activity in water reported in picocuries per liter (10^{-12} curies/liter) or 2.22 disintegrations per minute per liter.

Unconfined Ground Water - Ground water in the zone of saturation not confined beneath an impervious formation and moving under the control of the water table slope.

Water Quality - Those physical, chemical, biological, and radiological characteristics of water affecting its suitability for beneficial uses.

Water Quality Use Rating - The system of classifying water as suitable, marginal, and inferior quality for domestic and irrigation use used in this report. The rating used in this report is adapted to this particular area of investigation; it is based on the United States Public Health Service Standards for drinking water and the University of California Criteria for Irrigation Waters. In arriving at the rating, due consideration was given to such factors as climate, soil and crop types, physiological and aesthetic effects, and the availability of alternate sources of water.

Water Utilization - The employment of all waters by nature or man, whether consumptive or nonconsumptive, including that portion of the applied water which is irrecoverably lost.

Waste Water - The water that has been put to some use or uses and has been disposed of, commonly to a sewer or wasteway. It may be liquid industrial waste, or sewage, or both.

APPENDIX B

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APPENDIX B

BIBLIOGRAPHY

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APPENDIX C

WELL NUMBERING SYSTEM

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WELL NUMBERING SYSTEM

Locations and well numbers used in this report are referenced by use of the United States Public Land Survey System, and to the San Bernardino Base and Meridian or to the Mt. Diablo Base and Meridian. The well numbers consist of township, range, section number, a letter which indicates the 40-acre lot in which the well is located, and a final number which indicates the identity of the particular well within the lot. The subdivision of a section is shown below:

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

34

For example, 8N/12W-34P2, S. B. B. & M. is the second well to be identified in Lot P of Section 34 of Township 8 North, Range 12 West, San Bernardino Base and Meridian; 1N/26E-5J1, M. D. B. & M. is the first well to be identified in Lot J of Section 5 of Township 1 North, Range 26 East, Mt. Diablo Base and Meridian.

For well numbers where the letter X has been substituted for the letter designating the 40-acre lot, the X indicates there is insufficient control for assigning a more accurate location. For well numbers where the letter Z has been substituted for the letter designating the 40-acre lot, the Z indicates that the well is plotted from unverified location descriptions.